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EFFECTS OF COOKING METHOD, TYPE OF PACKAGE ADDITION AND FROZEN STORAGE ON THE QUALITY OF ROAST BEEF PREPARED IN A COOK-FREEZE FOODSERVICE SYSTEM

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Effects of cooking method, type of package addition and frozen storage on the quality of roast beef prepared in a cook-freeze foodservice system", submitted by Lynn Mary Roles in partial fulfilment of the requirements for the degree of Master of Science in Foods.

ABSTRACT

Beef roasts were cooked to 60° by the conventional institution (CONV), water bath (WB) and Alto-Shaam (AS) methods. Sliced roasts were packaged with gravy (GR) or carrageenan glaze (GLZ) in Traytite® containers (IND), or with GR in bulk containers (BLK). IND samples were evaluated fresh (FSH); IND and BLK samples were evaluated after cryogenic freezing and frozen storage (FZN-S). Reheated samples (80°) were evaluated subjectively and/or objectively.

Generally, IND FSH beef from each cooking method and package addition was desirable. IND FSH and IND FZN-S treatment comparisons indicate that for each cooking method, frozen storage significantly decreased grain, aroma desirability, beefy aroma and flavor intensity scores, acceptability and water holding capacity (WHC) of samples. The overall appearance of WB IND FSH beef was better ($P < 0.01$) than that of WB IND FZN-S samples. CONV FSH and CONV FZN-S beef were similar in flavor desirability and tenderness. WB IND FSH and AS IND FSH samples were rated significantly higher for flavor desirability and tenderness than comparable FZN-S samples.

Data for IND FZN-S beef indicate that samples from each cooking method were generally desirable. Cooking method did not affect the appearance, TBA and WHC values of IND FZN-S beef. While there were some differences, cooking method did not generally affect the aroma and flavor of IND FZN-S

samples. WB IND FZN-S slices were significantly better in tenderness, juiciness and acceptability than comparable CONV and AS samples. CONV IND FZN-S beef tended to be more tender and was more acceptable ($P < 0.05$) than comparable AS FZN-S beef. Shear values of WB IND FZN-S samples were lower ($P < 0.05$) than those of comparable CONV beef and tended to be lower than those of AS samples.

The appearance of GR FSH and GR FZN-S beef was similar. Frozen storage had a significant detrimental effect on the overall appearance, color, grain and doneness of GLZ beef. Aroma and flavor desirability, beefy aroma and flavor intensity, acceptability and WHC of GR and GLZ samples decreased significantly with frozen storage. There was no difference in WOA/WOF between GR FSH and GR FZN-S treatments; GLZ FSH samples had slightly but significantly more WOA/WOF than GLZ FZN-S samples. GR FSH samples were slightly more ($P < 0.01$) tender than GR FZN-S samples. Frozen storage had no effect on the tenderness of GLZ samples and on the juiciness, TBA and shear values of GR or GLZ slices.

Data for IND FZN-S beef show that GR samples were scored significantly higher for overall appearance, grain, beefy aroma and flavor intensity and juiciness than GLZ samples. WHC for IND GLZ FZN-S samples was higher ($P < 0.01$) than for GR samples.

For cafeteria-style BLK GR FZN-S beef, consumers rated the tenderness and juiciness of WB and CONV samples higher than those of AS samples.

These studies indicate that each cooking method and package addition generally produced desirable frozen-stored reheated beef. WOA/WOF was very slight in all samples. However, data suggest that all IND samples were dry. Although IND GLZ FZN-S slices were poorer in appearance than GR samples, GLZ was as effective as GR in maintaining the palatability of FZN-S beef.

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INTRODUCTION

The adoption of the cook-freeze system, cooking and freezing food for subsequent distribution and reheating at point of service, is a current trend in many institutional foodservice operations. Although production efficiency advantages of the cook-freeze system have been documented (Glew, 1973; Williamson, 1975; and Boltman, 1978), information on how cook-freeze procedures affect food quality is limited. According to a recent survey (National Livestock and Meat Board, 1981), roast beef appears more frequently than any other red meat on foodservice establishment menus. Due to the popularity of this item, any quality deterioration associated with institutional cook-freeze processes is of particular concern. Quality characteristics of roast beef most prone to deterioration due to cook-freeze-reheat procedures are tenderness, juiciness, aroma, flavor and overall acceptability (Bramblett et al., 1965; Baldwin and Korschgen, 1968; and Korschgen et al., 1970). Thus, investigations of the effects of processing alternatives in a cook-freeze system on the sensory attributes of cooked, sliced, reheated, ("ready-prepared") roast beef are essential.

Two low-temperature cooking techniques currently suggested for improving the yield, tenderness and juiciness of commercially-prepared roast beef are the hot-water bath and Alto-Shaam cooking methods. Although these procedures may have advantages over conventional cooking for roast beef

to be served immediately, no research devoted to effects of the water bath and Alto-Shaam cooking methods on the sensory characteristics of frozen-stored, "ready-prepared" roast beef has been found.

Preliminary work for this experiment and other findings (Chang et al., 1961; and Sato et al., 1973) suggest that oxidation-retarding techniques for the prevention of "warmed-over aroma" (WOA) and "warmed-over flavor" (WOF) may be required for frozen-stored, "ready-prepared" roast beef. Maillard browning reaction products formed by cooking beef slowly to high temperatures have been shown to inhibit WOF development in cooked, chilled beef slices (Huang and Greene, 1978). Thus, the water bath and Alto-Shaam slow cooking methods might be effective in reducing WOA/WOF in frozen-stored roast beef.

Quality deterioration has been shown to be greater in untreated frozen-stored roast beef slices than in comparable slices treated with an antioxidant or with gravy (Bramblett et al., 1965; Baldwin and Korschgen, 1968; and Korschgen et al., 1970). However, most health care facilities limit the use of chemical preservatives and, for many hospital patient meals, gravy is not allowed. A possible alternative to antioxidants or gravy for "ready-prepared" roast beef slices is a glaze made from carrageenan, a natural, inert, flavorless, gel-forming hydrocolloid. Studies on the potential of carrageenan glaze to protect the aroma, flavor and other quality attributes of cooked, frozen-stored roast

beef slices have not been found.

Although most studies have used thick meat slices, the thinner slices typically used in institutional foodservice may result in more quality alteration due to cook-freeze-reheat processes. In addition, published information on the individual-serving Traytite® packaging currently being used in some cook-freeze operations is unavailable. Furthermore, information on the acceptability of bulk-packaged, frozen-stored, "ready-prepared" roast beef in gravy is limited.

In order to establish cook-freeze procedures capable of ensuring high quality roast beef, the effects of processing techniques at various production stages on subsequent product quality must be determined. This study investigated the eating quality of cooked, sliced, reheated ("ready-prepared") roast beef prepared by the hot-water bath and Alto-Shaam cooking methods as compared with the conventional institution method. Cooked roast beef slices covered with gravy or with carrageenan glaze were packaged in individual-serving Traytite® containers and reheated immediately (as fresh controls) or after frozen storage. Treatment effects were evaluated both subjectively (by trained panels) and objectively (instrumentally and chemically). In addition, a consumer evaluation of frozen-stored, bulk-packaged, "ready-prepared" roast beef in gravy was conducted under cafeteria conditions.

LITERATURE REVIEW

The Cook-Freeze System

Processing stages in a typical institutional cook-freeze operation include: food preparation, cooking, chilling, portioning and packaging (bulk or individual-serving), freezing, storage, transport in the frozen state and reheating at point of service (Glew, 1973; Millross et al., 1973; and Boltman, 1978). Continuous, scheduled, high volume food production is designed to maintain a specific inventory of meal components which are withdrawn for service as required.

Because food production is separated from consumption, the cook-freeze system has many advantages (Glew and Armstrong, 1981). Since there are no peak production or distribution periods, productivity is higher due to more efficient use of labor and equipment. Fewer highly qualified staff are needed and because there is no shift work, good staff are more easily obtained. The cook-freeze system facilitates accurate portion control, close monitoring of food quality and the opportunity to offer a selective menu with a wide variety of choice; these factors help minimize plate waste (Glew, 1973; and Boltman, 1978). Consumer studies (Glew et al., 1969/70; and Millross et al., 1973) have shown that food in a cook-freeze foodservice system can be at least as or more acceptable than food in a traditional operation. The cook-freeze system also has the

potential for producing food with higher nutritional value and less bacteriological hazard (Glew and Armstrong, 1981).

It is important for an efficient cook-freeze facility to have accurate ingredient control for the production of standardized recipe formulae specifically developed for freezing and reheating (Williamson, 1975). Standardization of recipe methodology is essential to ensure consistency in all reheated food products. Initially, some foods must be undercooked because additional cooking occurs during reheating. Thus, roasting beef with thermometers to rare or medium doneness may be appropriate.

The next phase in the cook-freeze process, chilling the cooked food, should be carried out quickly. Chilling roasted meats makes slicing easier before packaging (Boltman, 1978). To ensure high quality food, both organoleptically and microbiologically, delay between cooking and freezing should be avoided (Glew, 1973). Smith et al. (1981) recommend chilling whole, cooked roasts in an ice bath to lower the meat internal temperature quickly through the bacterial growth zone. Roast internal temperatures should be lowered to below 30° within approximately 2 h after cooking (Glew, 1973; and Boltman, 1978). In institutions, a more practical method for chilling large amounts of meat efficiently is to place the roasts in a walk-in refrigerator, allowing room for air to circulate between them (Glew, 1973). Roasts should not be sliced until immediately before packaging and freezing.

Bulk, whole meal and individual-serving packages are used in cook-freeze foodservice operations (Boltman, 1978). Packages may be made of plastic, aluminum, paperboard, carton/plastic laminate or combinations of various materials (Boltman, 1978; and Briston, 1982). Cooked roasts may be packaged whole or sliced before packaging to make them "ready-prepared" for quick service. A standard quantity of food must be placed in each package so required reheating times remain constant. The type of packaging used depends on the nature of the reheating facilities and on where the food is being served (Boltman, 1978). For example, bulk packaging is more suited to cafeteria or servery use while individual-serving packages of food may be better for hospital ward pantry service.

As soon as possible after cooking, chilling and packaging, the food must be frozen quickly. Freezing methods include: plate freezing, blast freezing (tunnel, belt and fluidized-bed), immersion freezing and cryogenic freezing (Boltman, 1978). Cryogenic freezing with liquid carbon dioxide (LCO_2) or liquid nitrogen (LN_2) is the most rapid method (Boltman, 1978). One type of cryogenic freezer consists of an insulated stainless steel tunnel with a stainless steel mesh belt conveyor to provide continuous operation. The food passes through the tunnel and is cooled to below 0° by means of LCO_2 or LN_2 sprays (Boltman, 1978). Because LCO_2 or LN_2 released at atmospheric pressure boil at at very low temperatures, evaporative and forced convection

cooling of the food take place. The cold vaporized gas may be circulated by fans for more efficient, rapid cooling of the food (Glew, 1973). Sealing of the food packages may be done before or after freezing, depending on the type of packaging.

If cooked food is stored at or below -18°, quality deterioration is much slower than if the storage temperature is higher (Glew, 1973). Mobile freezer rack modules which hold up to 250 kg facilitate ease of inventory control and stock rotation in the "freezer food bank" (Williamson, 1975). Food quality generally decreases as length of frozen storage increases (Glew, 1973). However, the maximum freezer storage period for high turnover rate items such as roast beef is likely to be approximately three weeks.

Frozen food is usually transported to outlying user locations for a brief interim storage period before use in cafeterias, serveries or ward pantries. To shorten reheating times, bulk packages of frozen food are often tempered before reconstitution. Individual-serving packages of food may be reheated quickly from the frozen state. In some systems, food is plated before reheating and in others after reheating. Several reconstitution methods are available: convection ovens, microwave ovens, radiant-heat ovens, steamers, high pressure steamers or boiling water (Boltman, 1978). Some reheating methods are more suited for particular food items. However for ward pantries, the convection oven is recommended because it is capable of

heating a large number of patient meals relatively quickly (Boltman, 1978). In a convection oven, a fan circulates the hot air around the food packages and a rapid recovery of air temperature occurs after the oven is filled with frozen food. The microwave oven is often used as a backup reconstitution method for off-peak periods (Boltman, 1978). To ensure they are microbiologically safe and hot enough when they reach the consumer, foods are generally reheated to an internal temperature of at least 75° (Boltman, 1978).

High quality food in a cook-freeze foodservice system can be assured through daily, ongoing evaluation of reheated food products according to preset criteria; if the criteria are not met, appropriate feedback and corrective action must be taken (Halling and Frakes, 1981). Consumer evaluation of food quality as well as a program for microbiological testing of food products are also essential (Halling and Frakes, 1981).

Warmed-Over Aroma and Flavor

A significant problem with the increasing use of cooked, stored (chilled or frozen), reheated meats in foodservice facilities is the loss of the "fresh-cooked" flavor and the development of a rancid off-aroma and off-flavor in these products (Sato and Herring, 1973; Nielsen and Carlin, 1974; and Rhee and Ziprin, 1981). Development of WOA/WOF occurs very rapidly in cooked (particularly ground or sliced) meat exposed to air at refrigerator temperature and more slowly at

freezer temperature (Chang et al., 1961; and Sato et al., 1973). Reheating contributes to further development of rancidity in cooked meat (Sato and Herring, 1973; and Rhee and Ziprin, 1981).

Previous studies with cooked beef have shown that aroma and flavor scores tend to decrease with frozen storage and reheating of the product. Baldwin and Korschgen (1968) and Korschgen et al. (1970) noted lower scores for the aroma and flavor of frozen-stored (one to three months at -19° to -22°), reheated roast beef slices (0.65 cm to 1.75 cm thick) than for those of fresh reheated slices. Jakobsson and Bengtsson (1972) observed a significantly lower flavor score for cooked beef slices (1.5 cm thick) stored (-20°) for two months than for fresh reference samples. However, no differences in off-flavor scores were found (Jakobsson and Bengtsson, 1972). Haymon et al. (1976) stored cooked beef slices (1.9 cm thick) at -18° and found that samples stored for four weeks had significantly more oxidized flavor than comparable fresh meat samples.

WOA/WOF in meat is generally accepted to result from lipid oxidation, an autocatalytic chain reaction initiated with the production of unstable free radicals from polyunsaturated fatty acids containing nonconjugated double bonds (Sato and Herring, 1973). Propagation of the oxidation reaction occurs with the formation of hydroperoxides when free radicals combine with molecular oxygen. Secondary reaction products of hydroperoxide decomposition (alcohols,

aldehydes, ketones, acids, lactones and unsaturated hydrocarbons) are responsible for WOA/WOF (Sato and Herring, 1973).

Phospholipids, which are very unsaturated, are the major contributors to oxidation in beef (Wilson et al., 1976; and Igene and Pearson, 1979). Igene et al. (1980) reported that during frozen storage of meat at -18°, phospholipids oxidize first, followed by triglycerides after a prolonged induction period. Free nonheme ferrous iron has been shown to be an important catalyst in meat lipid oxidation (Sato and Hegarty, 1971; and Love and Pearson, 1974, 1976). Cooked meats develop oxidative rancidity much more readily than raw meats (Wilson et al., 1976; and Rhee and Ziprin, 1981). The release of bound heme iron when meat proteins are heated just enough to denature them (Igene et al., 1979) and the fact that cooked meat has a higher phospholipid content, in particular phosphatidyl ethanolamine, than raw meat (Campbell and Turkki, 1967; and Igene et al., 1981) are influencing factors. Thus, significant factors which enhance lipid oxidation in meat include: oxygen (particularly in ground and thinly-sliced meats which have more surface area exposed), phospholipids (more concentrated in cooked meats) and metals (particularly ferrous iron released from heme compounds during heat treatment).

Considerable research has focused on methods for inhibiting WOA/WOF development in cooked meat. Chemical compounds and chelating agents such as ethylenediamine

tetra-acetic acid (EDTA), propyl gallate, nitrites, butylated hydroxyanisole (BHA), tocopherols and sodium tripolyphosphate with ascorbic or citric acid possess antioxidant activity (Chang et al., 1961; Sato and Hegarty, 1971; Sato and Herring, 1973; Haymon et al., 1976; Fooladi et al., 1979; Igene and Pearson, 1979; Igene et al., 1979; and Rogstad, 1980). Exclusion of air also inhibits lipid oxidation (Sato and Herring, 1973).

Various naturally occurring substances including polyphenolic compounds from soy protein (textured vegetable protein), oilseed proteins, vegetable extracts and spices have been reported to inhibit WOA/WOF (Chipault et al., 1956; Pratt and Watts, 1964; Sato et al., 1973; Sangor and Pratt, 1974; Pratt and Birac, 1979; Younathan et al., 1980; and Rhee and Ziprin, 1981). Reducing compounds produced in the Maillard browning reaction also have antioxidant effects (Sato et al., 1973; Lingnert and Eriksson, 1980a, 1980b; and Lingnert and Lundgren, 1980).

A frequently used measure of the degree of lipid oxidation in meat is the thiobarbituric acid (TBA) value (Tarladgis et al., 1960). The TBA test is the quantitative determination of malonaldehyde, a secondary product of lipid oxidation. Baldwin and Korschgen (1968) found no correlation between sensory and TBA data for frozen-stored roast beef. In a project where inexperienced panelists rated ground beef samples for intensity of oxidized flavor, Greene and Cumuze (1981) reported significant but low

correlation coefficients between sensory scores and TBA values. Correlation coefficients for TBA values and sensory scores were higher for a subgroup from the population determined to be statistically consistent in scoring (Greene and Cumuze, 1981). In contrast, others (Jakobsson and Bengtsson, 1972; and Younathan et al., 1980) have found highly significant correlations between panel off-flavor scores and TBA values for cooked, stored beef.

Studies show that the relationship between absolute TBA values and taste panel scores for degree of WOA/WOF is variable. Tarladgis et al. (1960) reported that TBA values of 0.5 to 1.0 are in the range for WOF detection in meat. Cross and Kotula (1978) concluded that WOF is first perceived when the TBA value becomes higher than 1.0. In a recent study with consumer panelists, Greene and Cumuze (1981) found that the TBA number range in which oxidized flavor was first detected was 0.6 to 2.0.

In an experiment with sliced roast beef stored frozen for 11 to 164 days, Chang et al. (1961) reported odor scores of 2.2, 2.4, 2.7 and 3.5 (very strong off odor = 1 to none = 6) for samples having TBA values of 4.9, 2.3, 3.5 and 4.1, respectively. Bowers and Engler (1975) noted stale aroma and flavor scores of 3.6 to 4.0 (absent = 1 to very intense = 7) for cooked reheated ground beef having a mean TBA value of 0.346. In contrast, a WOF score of 2.2 (absent = 0 to very strong = 6) for reheated ground beef with a TBA value of 2.33 was reported by Younathan et al. (1980). Haymon et

al. (1976), in a study involving frozen cooked ground beef, obtained scores of 8.5, 3.0 and 1.0 (most oxidized flavor = 1 to least oxidized flavor = 9) for samples with TBA values of 0.9, 3.0 and 3.6, respectively. Huang and Greene (1978) noted a mean flavor score of 1.6 (no oxidized flavor = 1 to strong oxidized flavor = 4) for ground beef having a TBA value of 1.3. Samples with TBA values of 0.5, 5.2 and 9.6 received flavor scores of 2.1, 3.1 and 3.4, respectively (Huang and Greene, 1978).

These data (Chang et al., 1961; Bowers and Engler, 1975; Younathan et al., 1980; Haymon et al., 1976; and Huang and Greene, 1978) show that the relationship between WOF detection by taste panelists and the TBA test is variable and inconsistent. Dawson and Schierholz (1976) suggested that absolute TBA values may not be reliable indicators of the extent to which WOA/WOF will be perceived subjectively, because the products contributing to the TBA value are produced and recombined in systems in a variable manner. Although there is no chemical test which always corresponds to sensory scores, relative treatment effects in an experiment can be evaluated using the TBA value as a measure of oxidative rancidity.

Cooking Method

There are few published studies devoted to the effects of cooking method on the quality of frozen-stored "ready-prepared" roast beef. However, previous researchers have

used a variety of cooking methods in investigations of other treatment effects on frozen-stored roast beef quality.

Several workers (Korschgen et al., 1964; Baldwin and Korschgen, 1968; and Rappole, 1972) have used an "interrupted" cooking procedure whereby beef roasts are cooked to very rare, thickly sliced (about 1.75 cm), frozen, stored and later reheated. Korschgen et al. (1964) and Baldwin and Korschgen (1968) noted lower taste panel scores for frozen-stored beef than for fresh control samples. However, the flavor, tenderness, juiciness and overall acceptability scores for the meat indicated that the "interrupted" cooking procedure generally resulted in a good product after up to 12 months of frozen storage (Korschgen et al., 1964; and Baldwin and Korschgen, 1968). Rappole (1972) cooked rib eye roasts slowly (121°) to very rare (32°). The thickly-sliced samples were frozen and stored (one to five weeks) for subsequent reheating (to 43° to 49°). A taste panel rated the beef slices as acceptable for flavor, color and tenderness; a consumer evaluation also indicated that the product was acceptable (Rappole, 1972).

Many researchers (Cover, 1937; Bramblett et al., 1959; Hunt et al., 1963; Bramblett and Vail, 1964; and Nielsen and Hall, 1965) have investigated the potential of low-temperature/long-time roasting in improving beef tenderness and juiciness. During the heating of meat, structural and chemical changes occur, particularly in the collagenous connective tissue and contractile myofibrillar proteins.

Cooking tenderizes connective tissue but coagulates and toughens myofibrillar protein; the former becomes more pronounced with increased cooking time and the latter with increased temperature (Lawrie, 1974). Tenderization and softening of structural collagen with minimum toughening and hardening of the muscle fibers (due to heat coagulation of myofibrillar proteins) and with minimum sarcomere shortening and meat fiber shrinkage are desirable effects of the heating process (Bouton and Harris, 1972; and Lawrie, 1974). Low-temperature/long-time cooking procedures may result in collagen solubilization with minimum myofibrillar protein overcoagulation and would thus be justified for meat cuts containing much connective tissue (Lawrie, 1974).

Cover (1937) noted that well-done chuck and rump roasts were more tender when cooked at 125° than at 225°. Bramblett et al. (1959) found that foil-wrapped beef round roasts cooked at 63° for 30 h were more tender and juicy than comparable roasts cooked at 68° for 18 h. Roasts cooked at the lower temperature also had a smaller percentage cooking loss (Bramblett et al., 1959). In contrast, Hunt et al. (1963) found that oven temperatures of 93° to 196° had no significant effect on yield, total losses and Warner Bratzler shear values of 4.5 kg beef round roasts cooked by dry heat. Bramblett and Vail (1964) found that foil-wrapped beef round muscles of medium doneness (65°) cooked at 68° were more tender, had a better appearance and flavor, but demonstrated greater cooking losses and were

less juicy than paired muscles cooked at 93°. Nielsen and Hall (1965) noted that blade roasts but not rump roasts dry-roasted at 107° to 71° were more tender than comparable roasts cooked at 163°.

Several workers have used low-temperature methods for roasting beef to various stages of doneness for slicing, freezing, storage and subsequent reheating. Bramblett et al. (1965) cooked foil-wrapped beef round roasts to an internal temperature of 65° at oven temperatures of 68° and 93°. Slices (3 cm thick) of cooked beef were frozen in gravy, stored (-30°) for 0 to 12 months and then reheated. Generally, meat cooked at 68° was scored higher for appearance, juiciness, flavor and tenderness than comparable samples cooked at 93°. However, meat cooked at either temperature was rated desirable even after 12 months of frozen storage (Bramblett et al., 1965).

Korschgen et al. (1970) cooked foil-wrapped beef round roasts to 71° at a temperature of 85°, then reheated and evaluated the cooked meat slices (0.65 cm thick), either immediately after packaging or after 1 day to 12 months of frozen storage (-19° to -22°). The aroma, flavor, tenderness, juiciness and general acceptability of beef slices cooked by this method (Korschgen et al., 1970) were generally good, after up to 12 months of frozen storage.

In a hospital cook-freeze foodservice system, initial roasting[1] of beef to the rare stage may be appropriate to obtain reheated roast beef that is not dry and overcooked.

[1]See Appendix, page 167.

To date, the hot-water bath cooking method for rare beef has not been investigated for the production of frozen-stored "ready-prepared" roast beef. In the water bath procedure, roasts packaged in heat resistant, evacuated, nylon or polyolefin bags are cooked slowly by immersing the roasts in a vat of circulating hot water maintained at a temperature near the desired final internal meat temperature. Proponents of commercial low-temperature water bath cooking of beef suggest that this method can achieve cooked roast yields of up to 88% to 90% (Griffiths, 1976). Buck et al. (1979) tested water bath cooking for the preparation of rare beef to be served immediately. Longissimus, semimembranosus, semitendinosus, biceps femoris and rectus femoris muscles (1 to 4 kg) were cooked to 60°, either by a slow, dry-heat method (94°) or in evacuated, heat stabilized nylon bags in a hot-water bath (60° to 61°). Water bath-prepared roasts had significantly lower cooking losses, higher press fluid values, lower Warner Bratzler shear values and higher tenderness and overall acceptability scores than paired roasts cooked by the slow, dry-heat method (Buck et al., 1979).

Ray et al. (1981) cooked pre- and post-rigor semitendinosus and semimembranosus roasts to 66° in partially evacuated Cryovac® (polyolefin) bags in a commercial hot-water bath. The water temperature, initially at 46.5°, 52.1° or 57.7°, was raised 5.6°/h until it reached 80.1°. After cooking, roasts were chilled 12 h at 2°. The

tenderness of pre-rigor beef cooked by the method where the initial water temperature was 46.5° (i.e. the slowest method) (Ray et al., 1981), as evaluated by a trained panel and by a Warner Bratzler shear, was acceptable and equal to that of paired post-rigor roasts.

A recent study (Dinardo et al., 1982) determined the quality characteristics and yield of beef cooked by the water bath method and by slow, dry heat. Beef rib and round roasts (1 to 3 kg) were cooked either in an oven (94°) to 60° or were placed in evacuated nylon bags and cooked to 60° in a circulating hot-water bath (60°). Roasts were held at 60° in the bath for 0 h, 2 h or 4 h to determine the effects of extended cook times. Water bath-prepared beef gave lower cooking losses, greater yields and a more uniformly rare slice appearance as shown by sensory color evaluations and Gardner Colorimeter readings than meat cooked by slow, dry heat. In addition, beef samples cooked by the water bath method had lower Warner Bratzler shear values and higher tenderness and juiciness scores than comparable samples cooked by slow, dry heat. As well, the flavor of water bath-prepared roast beef was comparable to that of oven-roasted samples. Extended holding of meat (for 0 h to 4 h) in the water bath resulted in decreased yields, decreased overall rareness, increased collagen solubility, lower Warner Bratzler shear values and decreased juiciness and flavor scores (Dinardo et al., 1982).

Machlik and Draught (1963) reported that in the

temperature range of 60° to 64°, the collagen shrinkage reaction is quickly completed while the toughening process which occurs at higher temperatures is avoided. Others (Bramblett et al., 1959) have reported that the time meat is in the temperature zone of 57° to 60° is the significant factor in softening connective tissue while still maintaining tenderness in myofibrillar proteins. The tenderness in water bath-cooked beef may have resulted from the holding of samples in the temperature range conducive to enzymatic tenderization for longer than oven-prepared roasts. Brady and Penfield (1981) found that hydroxyproline solubilization was greater in water bath-cooked beef samples than in roasts cooked by dry heat. Dinardo et al. (1982) also suggested that collagen solubilization may account for the tenderness observed in water bath-prepared roast beef cooked to 60°.

Because it results in a fast rate of heat penetration through the temperature zone most conducive to bacterial growth (23.9° to 51.7°), the water bath cooking method for rare beef has been shown to be microbiologically as safe as a traditional, low-temperature, dry-heat cooking method (Smith et al., 1981). Meat cooked in a water bath should be held at an internal temperature of 60° for 12 min following cooking to help ensure a safe rare product (Smith et al., (1981).

Thus, the water bath method results in a higher yield and more tender, juicy, uniformly rare and equally flavorful

beef compared to beef roasted by low-temperature, dry heat (Buck et al., 1979; and Dinardo et al., 1982). However, it is not clear whether these same advantages can be expected if the water bath process is used in preparing roast beef in cook-freeze operations. Other advantages of the water bath cooking technique are reduced energy costs and precise control over degree of doneness (Dinardo et al., 1982).

The Alto-Shaam cooking method is another popular procedure for the commercial preparation of rare roast beef. This technique may produce greater cooked meat yields and a more tender, juicier product than conventional cooking methods. However, published reports to support these theories are unavailable. Furthermore, there is no information on the effects of Alto-Shaam cooking on the quality characteristics of frozen-stored, "ready-prepared" roast beef. The Alto-Shaam oven is a pressure-closed cooking cavity with thermal cables surrounding the oven chamber (Kamikawa et al., 1979). Alto-Shaam cooking may be comparable to roasting meat slowly in an enclosed container such as an oven film bag. Vollmar et al. (1976) cooked top round roasts (1.35 kg) at 94° either by dry heat or in oven film bags to an internal temperature of 60°. The palatability of the meat from both treatments was acceptable (Vollmar et al., 1976).

The Alto-Shaam cooking method may be microbiologically safer for roasting beef to rare than conventional, low-temperature, dry-heat methods. Goodfellow and Brown (1978)

found that dry-oven roasting of beef at 107° to an internal temperature of 57.2° was not adequate to eliminate 10^7 inoculated Salmonella from the meat surface. However, the high humidity (above 95%) generated in an Alto-Shaam oven resulted in elimination of Salmonella from roast surfaces at internal temperatures as low as 48.8° (Goodfellow and Brown, 1978).

Cooking method may also have an effect on the aroma and flavor of frozen-stored, "ready-prepared" roast beef. Early studies (Zipser and Watts, 1961) have shown that if beef is overcooked, lipid oxidation during storage is inhibited. Sato et al. (1973), in experiments with meat model systems, observed that when beef was subjected to high heat treatment (for example in the retort process) Maillard browning reactions occurred. These reactions resulted in the formation of reducing compounds which possess antioxidant activity and inhibit WOF development in cooked meat. Reducing compounds may act as oxygen scavengers, free radical acceptors or hydrogen donors (Sato et al., 1973).

Huang and Greene (1978) found that if beef was cooked to high internal temperatures and/or subjected to long, slow cooking and subsequently sliced and stored (4°), TBA values were lower than for samples cooked to lower internal temperatures or at faster rates. The TBA values of cooked, sliced, stored (4°) beef semitendinosus roasts which had been cooked at 92° decreased as the meat internal temperature was increased from 70° to 80°; however, TBA values did not

decrease in similar beef samples cooked at 163° (Huang and Greene, 1978). Huang and Greene (1978) attributed the TBA retarding activity in the beef cooked at 92° to the long heating time required to reach the final internal temperature. Roasts cooked at 92° also demonstrated more nonenzymatic browning. Thus, Huang and Greene (1978) concluded that cooking time and final roast internal temperature are major factors in the development of antioxidant substances. They (Huang and Greene, 1978) suggested that although heavy heat processing or overcooking may be necessary to produce TBA retarding substances in meat, the slow cooking and "cook-hold" methods employed in some foodservice operations may be suitable for investigation. Thus, the water bath and Alto-Shaam cooking methods warrant further study for the preparation of roast beef that is to be used in cook-freeze systems.

Package Addition

In addition to the influence of cooking method on the quality of "ready-prepared" roast beef, the treatment of cooked beef slices before freezing and storage may affect the sensory characteristics of the final reheated product. Several researchers have studied the quality of frozen, cooked, sliced beef packaged alone, with various antioxidant solutions and with gravies or sauces.

Korschgen et al. (1964) stored untreated, individually-wrapped slices of bottom round roasts (cooked by an

interrupted procedure) for eight days (-21°) before reheating. Freezing the slices without a package addition decreased flavor, tenderness, juiciness and general acceptability scores. Shear force values for the frozen-stored product were higher than for comparable samples reheated immediately after cooking. However, quality scores for the frozen-stored cooked beef slices indicated that the product was still desirable (Korschgen et al., 1964).

Jakobsson and Bengtsson (1972) compared the quality of cooked, sliced beef frozen with no package addition to that of fresh reference samples. Beef longissimus slices (1.5 cm thick) of medium doneness were packaged with no addition and were stored frozen (two months at -20°) before convection oven reheating to 65°. The flavor and juiciness of frozen-stored beef slices were significantly lower than those of freshly cooked reference samples. However, scores for off-flavor and tenderness were similar for both the fresh and frozen-stored product.

Published research comparing the effects of different package additions on the quality of frozen-stored "ready-prepared" roast beef is limited. Baldwin and Korschgen (1968) studied the effects of freezer storage (-22° for one day to 12 months) on the quality of cooked beef slices (1.75 cm thick) packaged with no addition and in an antioxidant dip. Control beef samples, reheated without frozen storage, were rated significantly higher for aroma and flavor than frozen-stored samples packaged either in an antioxidant dip

or with no addition. However, antioxidant-dipped samples were rated significantly higher for flavor than comparable untreated samples. For juiciness and general acceptability, control samples were scored similar to frozen, reheated antioxidant-dipped beef slices; untreated "ready-prepared" roast beef slices received significantly lower ratings for these quality attributes (Baldwin and Korschgen, 1968). Chang et al. (1961) found that ascorbate and polyphosphate antioxidant dips and cover solutions minimized WOA in refrigerated and frozen, sliced beef. Despite lower scores obtained for untreated frozen-stored beef, scores for all treatment variations indicated that the products were still desirable (Baldwin and Korschgen, 1968).

In a subsequent study (Korschgen et al., 1970), roast beef slices (0.65 cm thick), either untreated, covered with gravy or dipped in antioxidant, were packaged and then reheated either immediately after cooking or after frozen storage (one day to 12 months). Generally, all frozen-stored beef slices were judged to be desirable; however, antioxidant-dipped beef slices and slices covered with gravy received higher scores for aroma, juiciness and general acceptability than comparable untreated slices. For aroma, flavor, tenderness, juiciness and general acceptability, gravy-treated beef slices were preferred over both antioxidant-dipped and untreated samples. Their findings (Korschgen et al., 1970) concur with those of Bengtsson et al. (1972) who noted that cooked, frozen foods packaged in

gravy are higher in quality and have a longer shelf life than similar foods stored with no package addition. Other studies (Harrison et al., 1953; Bramblett et al., 1965; Baldwin et al., 1969; and Korschgen and Baldwin, 1971) have also shown that cooked meats in a gravy or sauce retain desirable sensory quality with frozen storage and reheating.

The ability of some gravies to preserve eating quality attributes in frozen-stored, reheated roast beef may be related, in part, to their ingredients. For example, the gravy used by Korschgen et al. (1970) contained butylated hydroxyanisole, an antioxidant which retards WOF development (Sato and Hegarty, 1971). In addition, wheat flour and artificial beef bases containing hydrolyzed vegetable protein might be expected to participate in Maillard browning reactions during reheating, producing antioxidant substances (Sato et al., 1973; Sangor and Pratt, 1974; Pratt and Birac, 1979; Lingnert and Eriksson, 1980a, 1980b; and Lingnert and Lundgren, 1980). Similarly, gravy containing drippings from beef cooked to a high temperature, beef cooked by pressure or beef cooked by a low-temperature method, might also be expected to contain antioxidant substances produced in nonenzymatic browning reactions (Zipser and Watts, 1961; Sato et al., 1973; and Huang and Greene, 1978). As well, the gravy flavor itself may mask flavor alterations in the meat caused by freezing, storage and reheating.

Research (Chang et al., 1961; Korschgen et al., 1970;

and Jakobsson and Bengtsson, 1972) has shown that exclusion of air from the package can also protect the quality of cooked, sliced beef stored chilled or frozen. In "ready-prepared" roast beef, gravy may preserve quality by preventing air from contacting the meat, thus inhibiting lipid oxidation (and resultant WOA/WOF), and by minimizing moisture loss from the meat slices during storage. Thus, the quality of untreated roast beef slices packaged in Traytite® containers might be expected to decrease with freezing and storage because there is an air space between the package contents and the lid in this type of packaging. Korschgen et al. (1970) packaged beef slices in either foil trays or boil in-pouch bags. Generally, scores for the flavor, juiciness and overall acceptability of frozen-stored beef slices in boil in-pouch bags were higher than those for beef slices in foil trays (from which it is difficult to exclude air). In addition, the least desirable samples were those in foil trays with no package addition. Gravied beef slices in foil trays received palatability scores comparable to samples packaged in boil in-pouch bags (Korschgen et al., 1970).

Most previous researchers have used thick meat slices in studies with frozen, reheated roast beef (Korschgen et al., 1964; Bramblett et al., 1965; and Baldwin and Korschgen, 1968). Thick slices should enhance quality retention in "ready-prepared" roast beef. However, the thinner beef slices typically required for institutional foodservice have

a larger exposed surface area which might result in greater moisture loss and deterioration of other quality characteristics during frozen storage and particularly during the reheating process.

Unfortunately, in hospitals many patients are not allowed to eat gravy. The addition of preservatives to meats for hospitalized patients is also considered undesirable. As well, Canadian Food and Drug Regulations (Health and Welfare Canada, 1981 - B.14.005) prohibit the use of chemical antioxidants on sliced or prepared roast beef.

Studies investigating the effects of carrageenan glaze in preserving quality characteristics of thinly-sliced, frozen, "ready-prepared" roast beef are lacking. Calcium iota carrageenan (Gelcarin 595), extracted from red marine plants (order Gigartinales), is a flavorless, freeze/thaw stable, inert polysaccharide. This compound is composed of 3,6 anhydro-d-galactose and sulfated d-galactose residues linked to form long chain polymers having molecular weights of several hundred thousand (Marine Colloids Division FMC Corp., 1981). About 25% of the weight of carrageenan is made up of ester sulfate groups. In aqueous solutions, carrageenan molecules remain in random coil structures. However, upon cooling, the hydrocolloid polymer chains form helices which then make up a three-dimensional polymer network; aggregation of the helical structures results in gel formation (Sharma, 1981). Thus, carrageenan is capable

of producing a medium strength water gel. A 0.5% calcium iota carrageenan solution in cold water exists in a relatively sticky, viscous form suitable for use as a glaze. However, since the aqueous gel formation is thermally reversible (Sharma, 1981), a carrageenan solution loses its viscosity upon heating. These properties make carrageenan suitable for glazing chilled sliced meats which are to be later reheated. Canadian Food and Drug Regulations (Health and Welfare Canada, 1981 - 172.626) permit the use of carrageenan in foods.

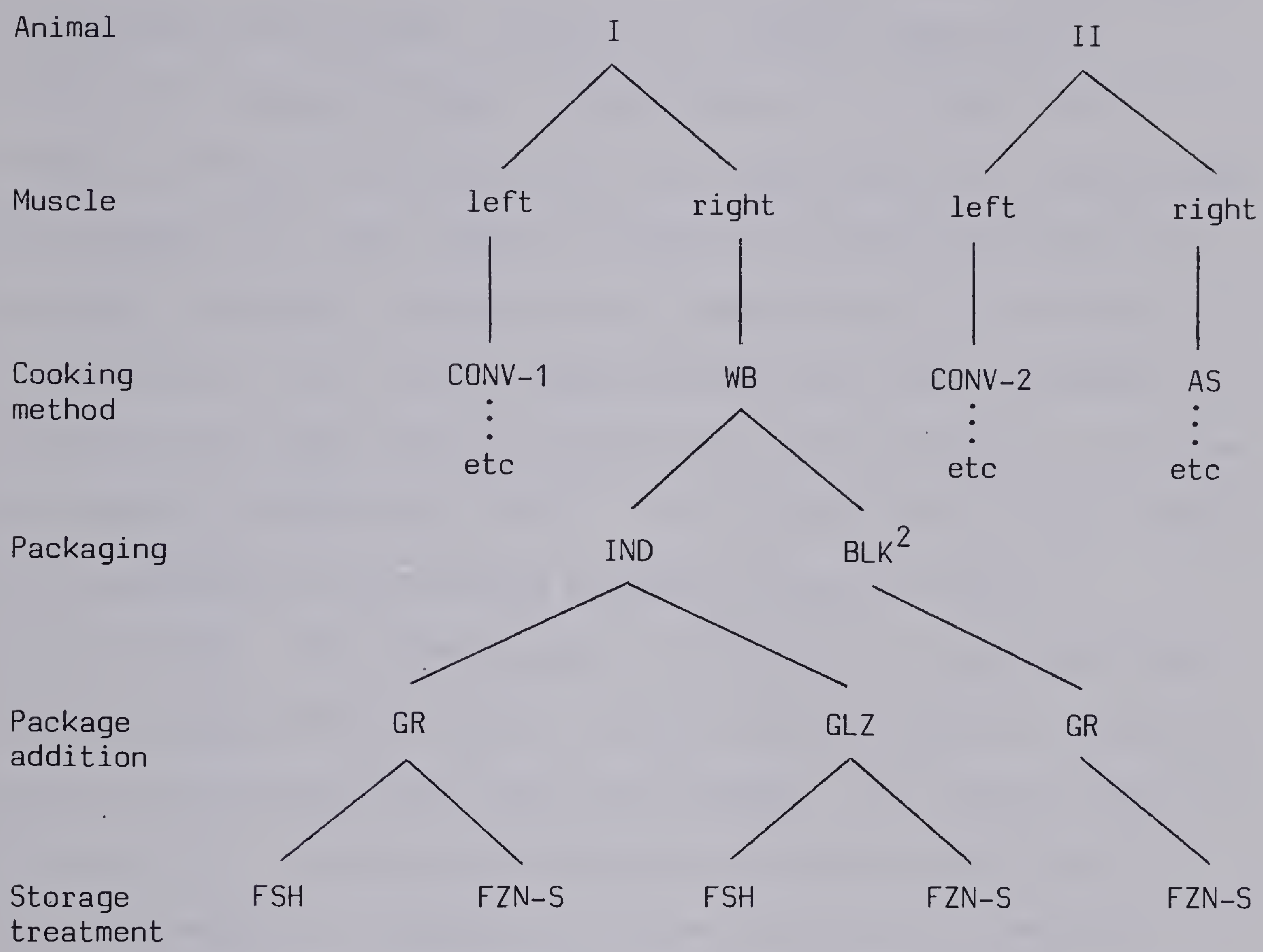
EXPERIMENTAL PROCEDURE

Experimental Design and Statistical Analysis

"Ready-prepared" roast beef packaged in individual-serving containers was evaluated according to an experimental design involving three cooking methods (conventional institution, hot-water bath and Alto-Shaam), two types of package additions (gravy and carrageenan glaze) and two storage treatments (fresh and frozen-stored). To minimize animal variation effects, the experiment plan used a "double-control" model for the three cooking method treatments: a muscle cooked by either the hot-water bath or Alto-Shaam method was paired with a muscle (from the same animal) cooked by the conventional method. Each cooked roast was split into package addition by cooking method treatment combinations which were further split into storage treatment by package addition by cooking method treatment combinations. Since one experimental replication made use of four muscles (two from each of two animals), the six replications required a total of 24 muscles (from 12 animals). An illustration of one experimental replication appears in Figure 1.

Data were subjected to analyses of variance. Sources of variation and degrees of freedom for the different parameters evaluated are shown in the Appendix; Tables 16 to 28, pages 132 to 148). Single degree of freedom comparisons (Chew, 1976; and Steel and Torrie, 1980) of each "test"

Figure 1. Design for one experimental replication[1].



CONV-1 and -2	Conventional institution (rotary gas oven)
WB	Hot-water bath
AS	Alto-Shaam
IND	Individual Traytite®
BLK	Bulk aluminum foil
GR	Gravy
GLZ	Carrageenan glaze
FSH	Fresh
FZN-S	Frozen-stored

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[1]Repeated six times; for three replications, CONV-1 and -2 were left muscles and for three replications, CONV-1 and -2 were right muscles.

[2]Evaluated by a consumer taste panel.

cooking method (water bath or Alto-Shaam) against its respective paired "control" method (conventional) and other comparisons were made (Figure 2). These comparisons involved cooking methods (Comparisons C1, C2 and C3), cooking method by package addition combinations (Comparisons C4 through C12) and cooking method by package addition by storage treatment combinations (Comparisons C13 through C17). Valid errors for testing these comparisons were computed by partitioning applicable replication interactions as outlined by Rowell and Walters (1976). For Comparisons C1, C2 and C3, the replication by cooking method interaction was partitioned. For Comparisons C4 through C12, interactions between replication and the eight cooking method by package addition combinations were partitioned. For Comparisons C13 through C17, interactions between replication and the 16 cooking method by package addition by storage treatment combinations were combined to form the error term.

In addition, certain means were compared using F-values from the analyses of variance; these comparisons included: gravy versus carrageenan glaze within storage treatment and fresh versus frozen-stored.

Missing data for trained taste panel evaluations in this experiment were handled by substituting, from a specific panelist's scores, values averaged over all replications (Appendix, Tables 21, 22 and 23, Footnote 6, pages 138 to 143). When computing valid error terms for testing the significance of panelist variation, the number

Figure 2. Single degree of freedom comparisons.

			Comparison[2]																
Treatment[1]			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
CONV-1			+		+														
WB			−		−														
CONV-2				+	−														
AS				−	+														
CONV-1	GR					+		+				+							
	GLZ								+		+	−							
WB	GR					−		−					+						
	GLZ								−		−		−						
CONV-2	GR						+	−				+							
	GLZ									+	−	−							
AS	GR						−	+						+					
	GLZ									−	+			−					
CONV-1	GR	FSH													+		+		
		FZN-S													−		−		
	GLZ	FSH														+	+		
		FZN-S														−	−		
WB	GR	FSH													+			+	
		FZN-S													−			−	
	GLZ	FSH														+		+	
		FZN-S														−		−	
CONV-2	GR	FSH													+		+		
		FZN-S													−		−		
	GLZ	FSH														+	+		
		FZN-S														−	−		
AS	GR	FSH													+				+
		FZN-S													−				−
	GLZ	FSH														+			+
		FZN-S														−			−

[1]See Figure 1, page 30.

[2]Comparisons are within column.

Comparison codes are:

[a]within either storage treatment (FSH or FZN-S)
[b]across both package additions (GR and GLZ)
[c]across all cooking methods (CONV-1 and -2, WB and AS)
[d]across CONV-1 and -2

Comparisons are:

C1[a,b] CONV-1 versus WB

C2[a,b] CONV-2 versus AS

C3[a,b] [difference between CONV-1 and WB] versus [difference between CONV-2 and AS]

C4[a] CONV-1 GR versus WB GR

C5[a] CONV-2 GR versus AS GR

(continued)

Figure 2 (continued).

C6[a] [difference between CONV-1 GR and WB GR] versus [difference between CONV-2 GLZ and AS GLZ]

C7[a] CONV-1 GLZ versus WB GLZ

C8[a] CONV-2 GLZ versus AS GLZ

C9[a] [difference between CONV-1 GLZ and WB GLZ] versus [difference between CONV-2 GLZ and AS GLZ]

C10[a,d] CONV GR versus CONV GLZ

C11[a] WB GR versus WB GLZ

C12[a] AS GR versus AS GLZ

C13[c] GR FSH versus GR FZN-S

C14[c] GLZ FSH versus GLZ FZN-S

C15[b,d] CONV FSH versus CONV FZN-S

C16[b] WB FSH versus WB FZN-S

C17[b] AS FSH versus AS FZN-S

of missing observations for a parameter was subtracted from the degrees of freedom for error. Missing chemical data were handled by substituting values averaged over all replications (Appendix, Tables 24 and 25, Footnote 6, pages 144 and 145).

To balance any "treatment order" effects, for every replication all preparation, sampling and evaluations of roast beef for sensory and objective measurements were performed according to complete and incomplete Latin square designs.

The statistical design for the portion of the study involving bulk-packaged, "ready-prepared" roast beef in gravy is described in a later section.

Experiment Overview

Throughout the description of the experimental procedure, "ready-prepared" roast beef refers to beef that has been cooked, chilled, sliced, packaged and reheated. CONV-1 and CONV-2, WB and AS refer to the conventional institution, hot-water bath and Alto-Shaam cooking method treatments, respectively (Figure 1). GR and GLZ indicate gravy and carrageenan glaze, whereas, FSH and FZN-S refer to the fresh and frozen-stored treatments, respectively. IND and BLK are used to indicate individual-serving Traytite® and bulk aluminum foil packaging (Figure 1).

The specifications for the equipment and materials used in the study are listed in the Appendix, Figure 8, page 149.

The six experimental replications were conducted over a six-week testing period. Twice weekly during the first three weeks, subjective and objective quality evaluations were made on IND FSH samples (eight cooking method by package addition combinations); during the remaining three weeks, similar evaluations were made on the IND FZN-S product (the same eight treatment combinations). A chronological flow chart of the experiment is shown in the Appendix, Figure 9, page 156.

The first day of a replication, roasts were cooked and chilled overnight. The second day, roast portions allocated to IND FSH, IND FZN-S and BLK FZN-S treatments were sliced and packaged with the appropriate package addition (GR or GLZ). IND FSH samples were reheated and evaluated immediately whereas IND FZN-S samples were frozen and stored for three weeks before being evaluated. BLK FZN-S samples were frozen and stored for an average of two weeks prior to evaluation by a consumer taste panel.

Meat Used for the Study

Eighteen young culled cows (average age 2.5 years) of mixed breeds (primarlily Beef Synthetic and Dairy Crossbreds) from the University of Alberta Beef Research Ranch at Kinsella were transported to an Edmonton meatpacking plant and slaughtered. Details of breeding, feeding and management of the animals were described by Price and Berg (1981).

After 24 h, the biceps femoris muscle was excised from each of the 36 sides, transported to the Edmonton Research Station Meat Laboratory, aged seven days (2°) and trimmed of fat. Twenty-four muscles (22 paired and 2 unpaired) of similar weight (average weight 4.6 kg) were selected as roasts for the study and delivered to the Home Economics Building, University of Alberta. Specific age, weight and breed information for the animals from which the muscles were taken is given in the Appendix, Table 29, page 157.

A 200 to 300 g portion, removed from the posterior end of each trimmed muscle, was wrapped, frozen and stored (-25°) for later chemical analysis; the remainder was used as a roast. Each weighed roast was packaged in a polyethylene bag and sealed with a twister. The roasts were frozen and stored (-25°) for 3 to 19 days.

The 24 roasts were randomly assigned to the cooking method treatments and the six replications (Figure 1). One roast from each of the two muscle pairs assigned to a replication was cooked conventionally in an institutional rotary gas oven; the remaining roast from a pair was cooked in either a hot-water bath or an Alto-Shaam oven. Two of the roasts for the sixth replication (CONV-1 and WB) were unpaired.

Prior to cooking, roasts were thawed in their packaging for a total of 87 h (48 h at 4° and 39 h at 2°).

Cooking and Chilling Procedures

Roasts were cooked by the conventional institution method at the Industrial Services Center (ISC) of the University Hospitals, an off-site cook-freeze food production facility. Roasts were cooked by the hot-water bath and Alto-Shaam methods in the Home Economics Building, University of Alberta.

To prevent curling of roasts during cooking, fine slits (about 1 mm deep) were made at approximately 3 cm intervals through the dense connective tissue along the proximal length of each roast. For cooking, each thawed roast was placed lengthwise with the medial surface up. Copper constantan thermocouples attached to Honeywell recording potentiometers were used to monitor roast internal temperatures during cooking, cooling and chilling.

After cooking, cooled roasts were chilled (2°) overnight for 15 to 18 h before slicing. For chilling, roasts were positioned well spaced in a large refrigerator (Bryan and McKinley, 1979) to allow for maximum air circulation and efficient cooling.

Conventional Institution Method (Rotary Gas Oven)

Each roast was placed on a rack (33 x 26 x 1.3 cm) in an aluminum roasting pan (41 x 29 x 5 cm) on the same shelf of a rotary (1 rev/80 sec) gas oven (Nicholson, model 5-26 110) maintained at 177°. A Fisher glass thermometer was inserted into the center of each roast to monitor internal temperature during cooking. Oven temperature was monitored

with a Taylor oven thermometer. All roasts were cooked to an internal temperature of 56° to 57°. To monitor post-oven internal temperature rise, two thermocouples were inserted into the center of each roast after its removal from the oven.

After cooling to 50°, each cooked roast was placed in a polyethylene bag, sealed, transported to the Home Economics Building, University of Alberta, and chilled.

Hot-Water Bath Method

Prior to cooking, two thermocouples were inserted into the center of each roast. Each roast was placed into a Cryovac®[1] cooking bag, a partial vacuum was drawn and the bag opening was sealed around the two protruding thermocouple wires (Ray et al., 1981) with a twister. The roast, with the top end of the cooking bag containing the thermocouple wires kept above the water line (Segars et al., 1976), was submerged in a thermostatically controlled, circulating hot-water bath (Precision Scientific, model 66802) preheated to and maintained at 61° (Buck et al., 1979). The water-bath temperature was monitored throughout cooking with a centrally-positioned thermocouple. Each roast was cooked to an internal temperature of 60° and then held at that temperature in the water bath for 12 min according to the recommendation of Smith et al. (1981).

After cooling to 50°, the roast and drip were removed

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[1]Made from a shrinkable, cross-linked, balanced, biaxially oriented polyolefin.

from the cooking bag and the cooked roast was placed in a polyethylene bag, sealed and chilled.

Alto-Shaam Method

In accordance with the manufacturer's instructions (Kamikawa et al., 1979) each roast was placed on a rack of an Alto-Shaam oven (model 750-TH-II) and two thermocouples were inserted into the center of the roast. An aluminum pan (41 x 29 x 5 cm) lined with aluminum foil was placed on the bottom of the oven to collect cooking drip from the roast. The roast and rack were positioned in the preheated oven (107°) so the meat was centered in the oven cavity. Inside oven door vents were closed. Oven temperature was standardized initially with a centrally-positioned thermocouple. Each roast was cooked to an internal temperature of 56° and allowed to stand at room temperature (23 ± 1°) until it reached the final temperature (~60°). After cooling to 50°, the cooked roast was placed in a polyethylene bag, sealed and chilled.

Objective Measurements - Whole Roasts

pH

A Fisher Accumet pH/ion meter (model 230) was used to determine the pH of each raw roast sample. A 20 g sample removed from the posterior end of each roast was blended with 100 mL distilled water for 60 sec. The homogenate was filtered into two beakers for duplicate pH determinations.

Fat and Moisture

The percentages of fat (ether extract) and moisture in each raw roast were determined by the methods of the Association of Official Analytical Chemists (AOAC, 1970). Samples (200 to 300 g) from the posterior end of the roast were thawed (4° for 24 h), trimmed of connective tissue, ground (20 sec), freeze-dried (24 h) and reground. For fat determinations, duplicate 2 g portions of each freeze-dried sample were placed on a Goldfisch extraction apparatus (18 h) and the resulting ether extract weighed. For moisture determinations, duplicate 2 g portions of each freeze-dried sample were oven-dried (105°) for 18 h and weighed.

Thaw Loss

For each roast, moisture loss during thawing was calculated as a percentage based on the weight of the raw roast before freezing.

Cooking Time

The cooking time in minutes and in minutes per kilogram (based on the raw, thawed roast weight) was calculated for each cooking method. Roast cooking time was calculated from an initial internal temperature of 4° to the time when the maximum internal temperature ($\sim$60°) was attained. The 12 min holding period was included in the cooking time for WB roasts.

Cooking and Chilling losses

Total cooking (volatile and drip), chilling drip and

and total cooking/chilling losses were determined and expressed as percentages, based on the weight of the raw, thawed roast.

Physical Characteristics - Changes in Roast Dimensions

The length, width and depth of each raw roast and of each cooked roast after chilling were measured. Increases or decreases in a dimension were calculated and expressed as positive and negative percentages respectively, based on the physical measurements of the raw roast.

Preparation of Package Additions

Gravy

The gravy was prepared according to the formula shown in Figure 3 (University Hospitals, ISC, 1981). A beef broth consisting of water, beef base and gravy mix was heated to 95° over direct heat in an 11 L aluminum kettle and held at this temperature for 5 min. A roux (margarine and flour) was cooked over medium heat until thick and bubbly (3 min). The roux was stirred gradually into the simmering beef broth and the mixture was reheated to 95°. Finally, a paste consisting of modified cornstarch and cold water was added slowly, with constant stirring, to the beef broth mixture. The gravy was then reheated to 95° and cooked over medium heat for an additional 5 min to remove any raw starch taste.

Carrageenan Glaze

The glaze was prepared using calcium iota carrageenan at a level of 0.5% according to the formula shown in Figure 4

Figure 3. Gravy formula.

Ingredients	Amount
Water	8.5 L
Beef base[1]	200 g
Gravy mix[2]	7 g
Margarine[3]	250 g
All-purpose wheat flour[4]	250 g
Modified waxy maize cornstarch[5]	125 g
Water	250 mL

[1]Stafford's Beef Consommé Mix (contains hydrolyzed plant protein, monosodium glutamate, salt, dextrose, caramel, spices and beef extract), Stafford Foods Ltd., Toronto, Ontario.

[2]Stafford's Gravy-O-Rich Gravy Mix (contains hydrolyzed plant protein, monosodium glutamate, salt, vegetable shortening, wheat flour and beef extract), Stafford Foods Ltd., Toronto, Ontario.

[3]Imperial Margarine, Monarch Fine Foods Co., Rexdale, Ontario.

[4]Robin Hood All-Purpose Flour, Robin Hood Multifoods Ltd., Willowdale, Ontario.

[5]Col-Flo 67 (powdered form, freeze-thaw stable), National Starch and Chemical Corp., New York, New York.

Figure 4. Carrageenan glaze formula.

Ingredients	Amount
Carrageenan[1]	10 g
Water	2.0 L

[1]Gelcarin® 595 calcium iota carrageenan, Marine Colloids Division FMC Corp., Springfield, New Jersey.

(Marine Colloids Division FMC Corp., 1981). In order to disperse and dissolve it, the carrageenan powder was sprinkled gradually on the surface of cold water in an 11 L aluminum kettle; the water and carrageenan were rapidly agitated for about 2 min.

After preparation, the gravy and carrageenan glaze were chilled (2°) for 14 to 19 h before use.

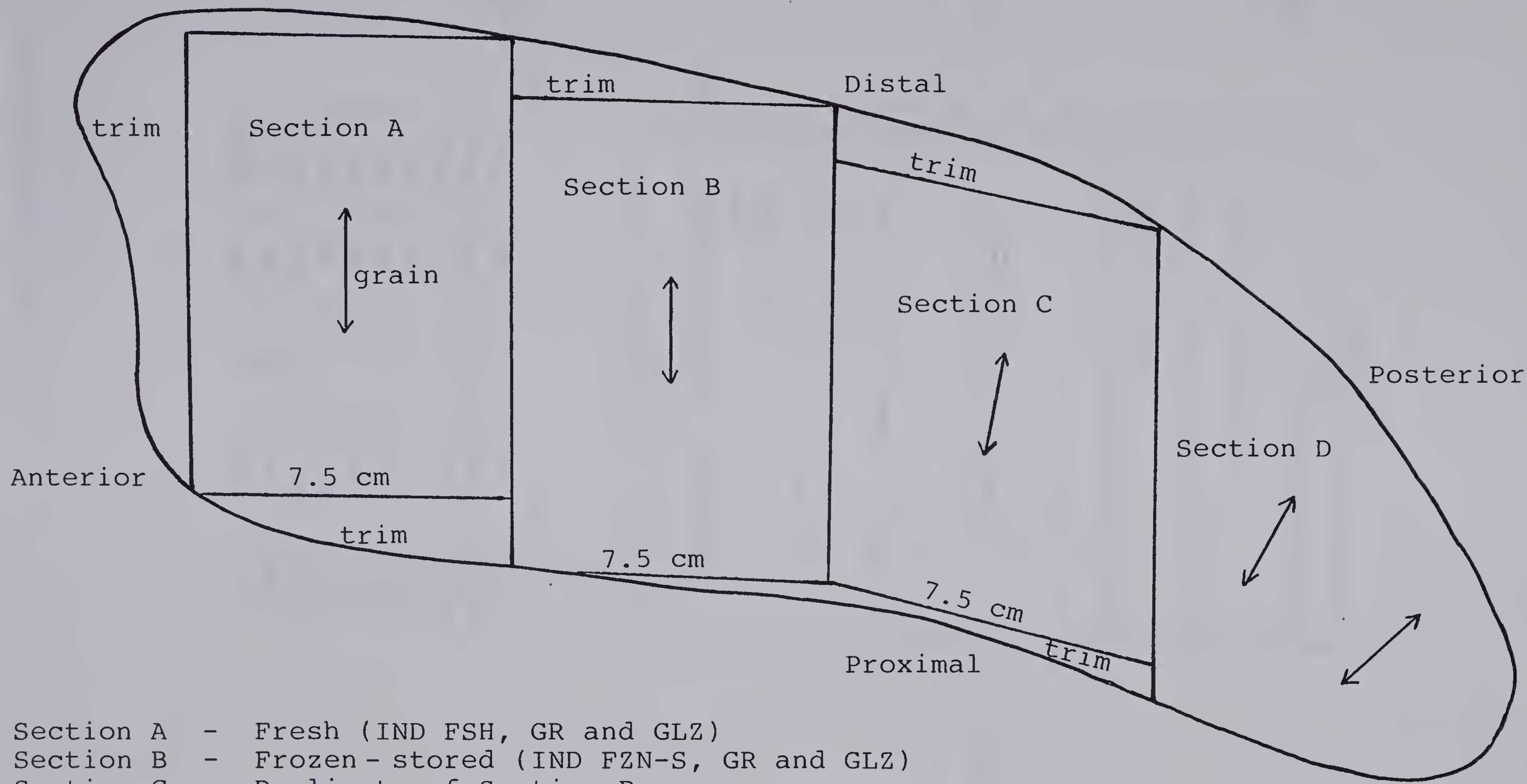
Slicing Procedures

All slicing procedures were standaridized during preliminary work. After overnight chilling (2°), the cooked roasts were sectioned as illustrated in Figure 5. Section A of each roast was removed first and sliced; the remaining intact roast portions were rewrapped and stored (2°) for an additional 3 h and then divided into Sections B, C and D and sliced.

All roast portions were sliced perpendicular to the grain on an automatic slicer (Berkel, model 1836) as shown in Figure 6. All beef slices were 4 mm in thickness except for those slices allocated to shear force determinations, which were 3 mm thick.

Immediately after sampling was completed, slices from Section A of each roast were packaged with gravy or glaze, reheated and evaluated as unfrozen fresh controls (IND FSH). Slices from roast Sections B, C and D were wrapped in plastic wrap and aluminum foil, chilled 30 to 60 min (2°) and transported in insulated styrofoam containers to the ISC

Figure 5. Sectioning plan for left biceps femoris roast.[1,2]



Section A - Fresh (IND FSH, GR and GLZ)
Section B - Frozen-stored (IND FZN-S, GR and GLZ)
Section C - Duplicate of Section B
Section D - Frozen-stored (BLK FZN-S, GR - consumer evaluation)

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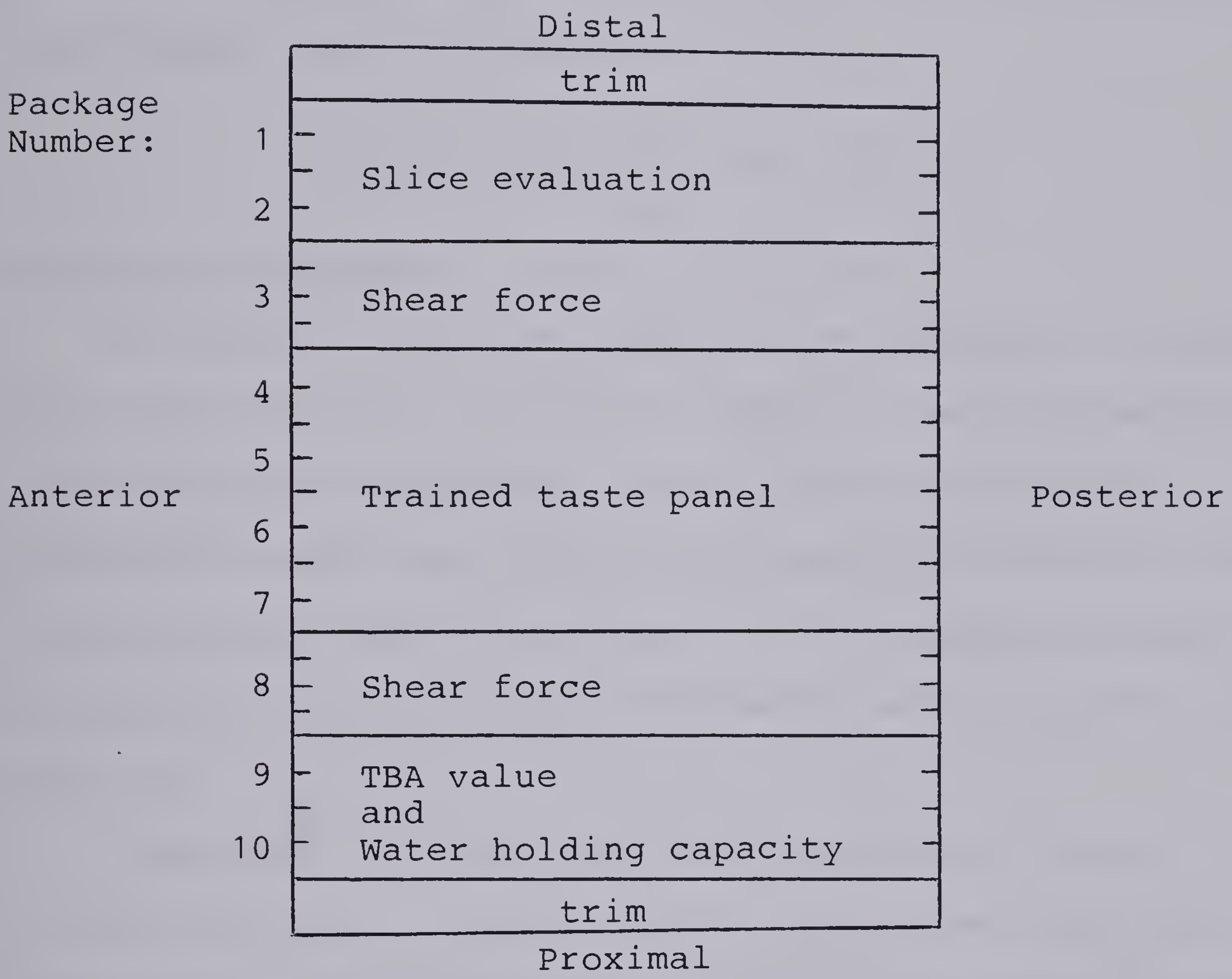
[1] Medial side facing up.
[2] See Figure 1, page 30.

Figure 6. Packaging plan for slices from Sections A, B and C of roasts.[1,2]



Package Number:

1 Two 4 mm thick slices, gravy
2 Two 4 mm thick slices, glaze
3 Four 3 mm thick slices, gravy
4 Two 4 mm thick slices, gravy
5 Two 4 mm thick slices, gravy
6 Two 4 mm thick slices, glaze
7 Two 4 mm thick slices, glaze
8 Four 3 mm thick slices, glaze
9 Two 4 mm thick slices, glaze
10 Two 4 mm thick slices, gravy

----

[1]Medial side facing up.

[2]See Figure 5, page 44.

for freezing. Section B of each roast was used for IND FZN-S treatments while Section D was used for the BLK FZN-S treatment (for evaluation by a consumer panel). Section C was prepared as a duplicate of Section B in case packages were damaged during mechanical lidding.

Packages for Individual Service

Packaging Procedures

As shown in Figure 6, separate IND packages of roast beef (from Sections A, B and C; Figure 5) were prepared for each objective measurement and for sensory evaluation. Packages of roast beef slices for immediate evaluation as fresh controls (FSH treatments) and for evaluation after freezing and storage (FZN-S treatments) were prepared in the same way.

Traytite® "S" individual-serving packages[1] (130 x 110 x 40 mm) were used for packaging the meat. Two 4 mm thick beef slices (approximately 60 g total) were placed in each of the packages (except for those allocated to shear force determinations which contained four 3 mm thick meat slices). Gravy (75 mL) was added to the packages allotted for GR treatments. Beef slices to be glazed were dipped individually into the carrageenan glaze, drained (3 sec) and placed into their packages.

Packages of roast beef to be evaluated immediately (FSH

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[1]Made from paperboard, Polyethylene Terephtalate (PET) laminated claycoated solid bleached sulphite (SBS).

treatments) were sealed with all-purpose aluminum foil. Packages of beef designated for FZN-S treatments were lidded, after freezing, with the specially-designed Traytite® lids and microwave sealed with a Sprinter mechanical lidder. All packages had an air space of approximately 2 cm between the surface of the contents and the lid.

Freezing and Storage Procedures

A liquid carbon dioxide (LCO_2) freezing system (Kryospray, model 4150) (-60°) was used to freeze the cooked, sliced roast beef. The center temperature of the packages of meat was monitored before and after freezing with a Bailey Instruments digital probe thermometer.

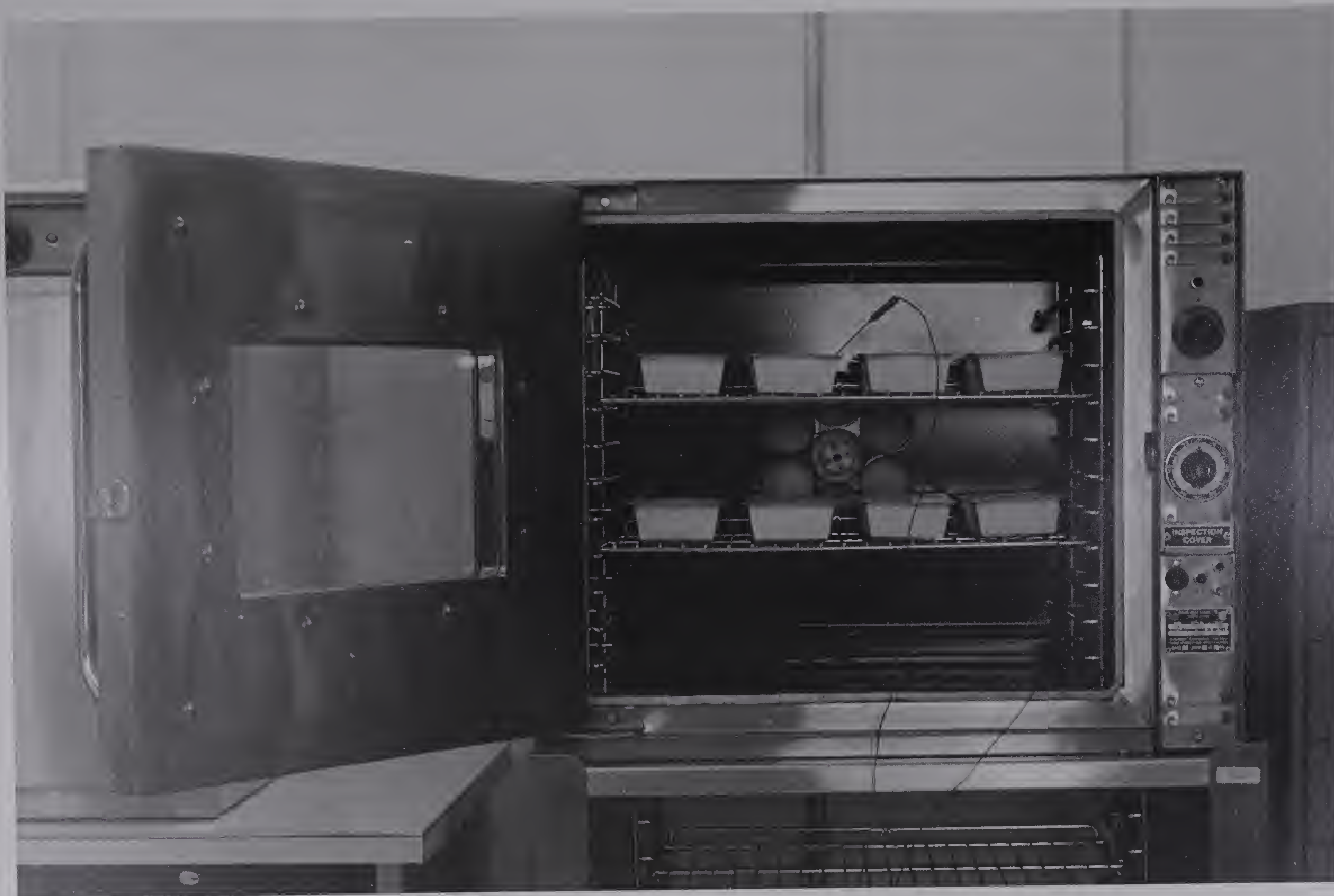
The same freezing tunnel conveyor speed was used for freezing all of the Traytite® packages of roast beef. The mean freezing time was 9 min 57 sec (range, 9 min 28 sec to 10 min 23 sec).

All packages of frozen roast beef were subsequently placed in a walk-in freezer (-15 ± 3°) for 2 h and then transported in styrofoam containers to the Home Economics Building, University of Alberta. Traytite® packages of roast beef were stored (-25°) for three weeks.

Reconstitution Procedures

All reconstitution procedures were standardized in preliminary work. During reheating, the internal temperature of the beef in Traytite® packages was monitored with copper constantan thermocouples attached to a Honeywell recording potentiometer.

Figure 7. Reheating Traytite® packages of "ready-prepared" roast beef in forced-air convection oven.


INSPECTION COVER

FSH beef samples (internal temperature, 10 ± 5°) were reheated immediately after packaging. To facilitate thermocouple insertion, prior to reheating, FZN-S beef samples were tempered at room temperature (23 ± 1°) to approximately -10°. Packages containing two 4 mm thick beef slices were tempered 45 min, while those containing four 3 mm thick slices were tempered for 60 min.

The packaged roast beef slices were reheated in a forced-air convection oven (Baker's Pride, model X-L300) at 177° to an internal temperature of 80°. A total of eight packages per rack were placed in the same relative location on each of two racks spaced at 16.5 cm intervals. GR and GLZ samples were reheated on separate racks; the placement of each was alternated from one rack to the other with every replication.

<u>Objective Measurements</u>

All objective measurements on beef samples in Traytite® packages were made on cooked reheated meat. Sampling techniques for the objective tests were standardized. Prior to sampling, the gravy or glaze was removed from all roast beef slices used for testing.

<u>Reheating Time</u>

Because reheating times were short, a stopwatch was used to monitor the time in minutes for packaged roast beef slices to reach an internal temperature of 80°.

<u>Thiobarbituric Acid Value</u>

Thiobarbituric acid (TBA) values, for the quantitative

determination of oxidative rancidity, were obtained by employing the distillation method of Tarladgis et al. (1960) on duplicate 10 g samples of each reheated roast beef sample.

For each determination, the cooled meat sample was blended for 90 sec with 50 mL distilled water, transferred to a Kjeldahl flask using an additional 47.5 mL distilled water and acidified with 2.5 mL of 4 N hydrochloric acid. The slurry was distilled for 10 min on a Kjeldahl apparatus until 50 mL of distillate was collected. A portion of the distillate (5 mL) was mixed with 5 mL of TBA reagent (0.02 M 2-thiobarbituric acid in 90% glacial acetic acid) in a stoppered test tube, warmed in a boiling water bath for 35 min and then cooled for 10 min under cold running water. The absorbance of the solution was read at 532 nm against an appropriate reagent blank using an Ultraviolet Spectrophotometer (Pye Unicam SP, model 1800). The wavelength for maximum absorption (532 nm) was determined by plotting the absorption spectra of a standard TBA, TEP (1,7, 3,3 - tetraethoxypropane) solution as outlined by Tarladgis et al. (1960).

Standard curves were prepared (Tarladgis et al., 1960) by making diultions of a $1x10^{-8}$ to $7x10^{-8}$ moles malonaldehyde per 5 mL TBA reagent and treated as a sample; absorbances were read at 532 nm.

A percent recovery determination was made (Tarladgis et al., 1960) by distilling (on a Kjeldahl apparatus) 100 mL each of seven acidified standard TEP solutions giving

malonaldehyde concentrations ranging from $2x10^{-6}$ to $1.4x10^{-5}$ M and treating as samples.

TBA values (milligrams malonaldehyde per kilogram of sample) were calculated by multiplying absorbances by the K constant 7.8 (Tarladgis et al., 1960).

Shear Force Measurements

Duplicate reheated samples were tested on an Ottawa Texture Measuring System (OTMS) equipped with a Kramer shear compression cell, using the method described by Hawrysh and Berg (1976). Two cooled (23 ± 1°) beef slices, cut into 6.7 x 3.3 x 0.3 cm pieces and weighing approximately 12.0 g, were placed in the standard shear compression test cell with the meat fibers positioned vertically. A 30 sec downstroke speed and a 100% range selection were used as operating parameters. Shear values were calculated as maximum force in kilograms per gram of sample.

Water Holding Capacity

The water holding capacity (WHC) of reheated roast beef samples was determined using the method described by Hawrysh and Berg (1976). Triplicate 0.5 g samples, taken from each of two cooled (23 ± 1°) beef slices, were placed individually between circles of Whatman No. 1 filter paper (15.0 cm in diameter) and aluminum foil (5.5 cm in diameter). The three samples were stacked alternately between four plexiglass plates and this unit was pressed in a Carver Laboratory Press under a pressure of 878.8 kg/cm^2 for 60 sec.

The areas of the pressed meat and the expressed fluid

imprinted on the filter paper were determined with a compensating planimeter (Hugh Owens, model 349-1838). As described by Miller and Harrison (1965), relative WHC was calculated by subtracting the ratio of the area of the pressed meat to the area of the expressed fluid from unity (the maximum expressible liquid index).

Sensory Measurements

Slice Evaluation

At each panel session, four experienced panelists, individuals from the staff of the Faculty of Home Economics, University of Alberta, each evaluated the appearance of the eight reheated roast beef treatments. After removing the gravy or glaze, two slices representing each cooking method by package addition combination were placed on separate, coded, white plates under a MacBeth Skylight set at daylight.

Panelists used a catergory scale scorecard (Appendix, Figure 10, page 158) to evaluate the color, grain, degree of doneness, uniformity of doneness and overall appearance of the roast beef slices. Color was rated on a scale of 5 (very good) to 1 (very poor), grain on a scale of 5 (fine) to 1 (very coarse), degree of doneness on a nine-point double-pointed scale of 5 (medium) to 1 (rare or well-done), and uniformity of doneness on a scale of 5 (same degree of doneness throughout slice) to 1 (marked ring effect). Overall appearance was rated on a scale of 5 (very desirable) to 1 (very undesirable). The order in which the four judges evaluated the eight samples was predetermined by three 8x8

Latin square designs divided in half; each judge evaluated the samples in a different order for every replication.

To ascertain possible causes of off-color or unusual surface characteristics such as iridescence, judges were asked to state reasons for assigning a score of 3 or less to the color or overall appearance of a sample.

Taste Panel Selection and Training

An eight-member taste panel consisting of graduate students and staff from the Faculty of Home Economics, University of Alberta, was selected and trained according to methods similar to those of Cross et al. (1978) and the guidelines of the American Meat Science Association (AMSA, 1977). A total of 15 candidates were selected for the initial screening process on the basis of their interest, availability and preference for roast beef. The screening process, designed to quickly eliminate individuals who could not descriminate large quality differences, consisted of a series of 12 triangle tests, three per day for each of four days. During screening, the ability of an individual to differentiate between fresh and warmed-over, juicy and dry, tender and tough roast beef samples was tested, since these were the attributes of roast beef of primary interest for the actual study. On the basis of a sequential analysis chart (Cross et al., 1978), 11 judges were selected for training.

Training sessions were conducted three to four times per week for seven weeks. The judges were gradually

acquainted with the evaluation procedure and introduced to the scorecard characteristics. The judges also assisted in the development of the final scorecard. Several training sessions were designed to familiarize the panelists with different levels of each quality attribute. During these sessions, brief discussions were held where judges helped each other to identify the extremes, the middle and other points on the seven-point scale for each quality characteristic. Throughout these and other sessions, panelists were made aware of the characteristics of high quality, freshly roasted beef.

During training, judges evaluated a wide variety of samples of roast beef including all treatments to be studied and many variations of fresh and frozen-stored, reheated samples. Warmed-over samples were obtained by storing cooked roast beef slices, either in the refrigerator or freezer, for varying lengths of time in different package types and subsequently reheating them to 80°. Samples with a weak aroma and flavor were prepared by packaging cooked roast beef slices in water and storing them in the freezer before tempering and reheating. Tender, moderately tough and tough beef cuts were roasted to rare, medium and well-done stages to provide judges with illustrations of samples differing in tenderness and juiciness. Various brands of beef broth made into gravies and dips were also added to packages of cooked roast beef in order to expose panelists to different bouillon-like flavors and aromas.

A total of nine characteristics considered to be important in "ready-prepared" roast beef were evaluated on a seven-point category scale, with 7 indicating the highest quality and 1 indicating the lowest quality. The instructions given to the judges and the scorecard appear in the Appendix, Figures 11 and 12, pages 159 and 161.

Judges were instructed to rate sample aroma after removing the lid from the container and smelling the sample three times. Flavor was evaluated with continued chewing of a sample. Desirability of aroma and flavor were evaluated on a scale of 7 (very desirable) to 1 (very undesirable). "Beefy" aroma and flavor were each evaluated on an intensity scale of 7 (very beefy) to 1 (very weak).

Intensities of WOA and WOF were evaluated on a scale of 7 (not detectable) to 1 (extremely strong). To standardize judges' scores for intensity of WOA and WOF, a food anchor was employed (McLandress, 1972; Forbes, 1973; and Smith, 1976). The preparation of this anchor (slices of cooked, reheated ground beef loaf) was standardized and is outlined in the Appendix, Figure 13, page 162. TBA tests were done (as outlined on page 49) on duplicate 10 g samples of the ground beef anchor. During training, judges established the ground beef anchor as being equivalent to a score of 4 (moderately intense) for WOA and WOF. The ground beef anchor also assisted judges in verifying the characteristics of WOA and WOF at the beginning of each taste panel session. Panelists were instructed to lift the container lid, smell

the ground beef anchor three times and to taste a slice of the anchor prior to evaluating roast beef samples for WOA and WOF intensity.

Juiciness (based on five chews of one 2 cm x 2 cm x 4 mm sample) and tenderness (based on the number of chews required to completely masticate a sample) were evaluated on a scale of 7 (very juicy or tender) to 1 (very dry or tough). A raisin (California dark seedless variety), chewed five times, was employed by the judges to standardize juiciness scores (Smith, 1976). During training, panelists established the raisin as being equivalent to a score of 5 (slightly juicy).

Overall acceptability was evaluated on a scale of 7 (very acceptable) to 1 (very unacceptable). Panelists were requested to indicate reasons for scoring 3 or lower for a particular palatability attribute and were also asked to describe the aroma and flavor of a sample by checking an appropriate descriptive term(s) from the lists at the bottom of the scorecard (see Appendix, Figure 12, page 161). Through their descriptions of the roast beef samples during training, judges assisted in specifying these descriptive terms which were discussed and standardized so all panelists held a common definition for each.

The performance of each of the 11 judges was evaluated twice, after four and seven weeks of training, according to a modified method of Cross et al. (1978). Candidates were ranked according to their ability to discriminate between

samples and to reproduce judgements of the same sample type consistently from session to session. On this basis, the eight best panelists and one alternate panelist were selected for the study.

Evaluation by Trained Taste Panel

The eight panelists each evaluated eight sets of coded reheated meat samples at every panel session using the procedures learned in training. Taste panel sessions were held at 10:20 am twice per week in an air-conditioned sensory panel room equipped with individual booths and white light.

All sampling procedures for trained taste panel evaluations were standardized during preliminary work. Four roast beef slices (two Traytite® packages) per each of the eight cooking method by package addition combinations were allocated for evaluation by the panel at each session. The gravy and glaze were removed from the roast beef slices before sampling. Four judges received samples from one package; the other four received samples from the second package. For each of the eight treatments, each judge received two samples (2 cm x 2 cm x 4 mm) from the center region of adjacent slices in the roast. Each panelist received one sample from the same location in both slices from one package. Relative sample position for a panelist was identical for every treatment in a replication and was rotated in a clockwise direction, one position every replication.

Samples were placed in coded individual Pyrex® custard cups (140 mL) and covered with glass lids. During the evaluation, the samples in the Pyrex® cups were kept warm (50°) by placing the cups over hot water (85°) in double boilers, made from nested Corning casserole dishes (900 mL), and holding these units on Salton electric Hotrays™ and Hotables™. To ensure that they were similar in temperature, all samples were held in this warming system for 10 min before each taste panel session. The eight samples were presented to the panelists in three sets. The first set consisted of two ground beef slices (2 cm x 2 cm x 5 mm) to anchor WOA/WOF plus two roast beef samples and the second and third sets consisted of three samples each.

Each panelist received a tray containing the coded reheated roast beef samples (two samples representing each cooking method by package addition combination), the food anchors for WOA/WOF and juiciness, a set of eight scorecards (Appendix, Figure 12, page 161), an individual chew range card (developed during training), a pencil, fork, napkin, expectoration cup and two toothpicks. To help eliminate flavor carryover between samples, panelists were also provided with unsalted soda crackers and room-temperature water (23 ± 1°) composed of two parts tap water to one part carbonated water (a modified recommendation of Hill and Glew, 1970; and Hill et al., 1977).

As described earlier, to balance "treatment order" effects, the judges evaluated the treatments according to

six 8x8 Latin square designs, one per replication; no two judges evaluated the samples in the same order.

Packages for Bulk Service

Statistical Design

"Ready-prepared" BLK GR FZN-S roast beef samples prepared by three cooking methods for six replications (see Figure 1, page 30) were evaluated by a consumer taste panel. Half of the panelists evaluated CONV-1 and WB samples while the other half rated CONV-2 and AS treatments. Each replication by roast pair (CONV-1/WB or CONV-2/AS) was designated as a cell; thus, there were 12 cells (six replications by two roast pairs). Observations were evenly distributed within cells (i.e. between paired roasts) but unevenly distributed among cells. Treatment means were computed on an unweighted basis according to the means for replications.

Data were subjected to analyses of variance. Sources of variation and degrees of freedom for the different parameters evaluated are shown in the Appendix, Table 28, page 148. Single degree of freedom comparisons (Chew, 1976; and Steel and Torrie, 1980) of each "test" cooking method (WB or AS) against its respective "control" (CONV-1 or CONV-2) as well as an indirect comparison (WB versus AS) were made (Comparisons C1, C2 and C3, Figure 2, page 32). Valid errors for testing these comparisons were computed by partitioning replication by cooking method interactions.

Processing Procedures

For the consumer evaluation, approximately 375 g of sliced beef (4 mm thick) from Section D of each roast (see Figure 5, page 44) was placed into each Ecko bulk aluminum foil package (214 x 151 x 46 mm) and covered with gravy (225 mL).

The LCO_2 freezing system described earlier was used to freeze the cooked, sliced roast beef in gravy. The meat temperature within the packages was monitored before and after freezing with a Bailey Instruments digital probe thermometer. The mean freezing time for BLK packages was 20 min 29 sec (range, 18 min 56 sec to 21 min 10 sec). The packages of frozen roast beef were sealed with aluminum foil, placed in a walk-in freezer (-15 ± 3°) for 2 h and then transported in styrofoam containers to the Home Economics Building, University of Alberta. BLK GR packages of roast beef were stored (-25°) for an average of two weeks before evaluation.

Tempering and reconstitution procedures for BLK GR packages of roast beef were standardized. Internal temperatures of the roast beef during reheating were monitored with copper constantan thermocouples attached to a Honeywell recording potentiometer. To facilitate thermocouple insertion prior to reheating, the packages of roast beef were tempered in a refrigerator (2°) for 16 h to an internal temperature of approximately -10°. The 24 packages, eight at a time, were reheated in a forced-air

convection oven (Market Forge, model M2600) at 177° to an internal temperature of 80°. Two packages were placed on each of four evenly spaced racks in the oven. To maximize air circulation, package positions on adjacent racks were staggered.

To ensure accuracy, a stopwatch was used to monitor the time in minutes for packages of roast beef to reach an internal temperature of 80°.

Sensory Evaluation by Consumer Panel

Volunteers from the staff of the University Hospitals participated in a consumer evaluation of BLK GR FZN-S samples representing three cooking method treatments (CONV-1 and CONV-2, WB and AS) and six replications. Sixty-two participants rated samples from the CONV-1 and WB treatments while 65 other consumers evaluated samples representing the CONV-2 and AS treatments. The evaluation was conducted between 2:00 and 3:30 pm in a large room in the University Hospital furnished with long tables placed end to end and with chairs arranged along one side.

For the evaluation, 24 BLK GR packages of roast beef were reheated (eight at a time) and held warm (75 ± 5°) on a mobile hot serving unit (Vollrath, model 99148) during three 30 min serving shifts. The warm roast beef slices were served on coded disposable white plastic plates.

Each panelist received a tray containing two coded roast beef samples in gravy and a scorecard (Appendix, Figure 14, page 163), pencil, fork, knife, napkin,

expectoration cup and glass of water (23 ± 1°). Panelists evaluated the appearance, tenderness, juiciness, flavor, temperature and overall acceptability of the samples on a five-point category scale, with 5 representing the highest score (Appendix, Figure 14, page 163). A list of descriptive terms was provided to aid consumers in the evaluation of flavor. Demographic information (age and sex) about each participant was also obtained. An example of a completed scorecard was posted and the judges were instructed to take a drink of water between tasting samples. Discussion during the evaluation was discouraged.

After completing the evaluation which required about 10 min, the panelists were served refreshments in an adjoining room.

RESULTS AND DISCUSSION

Throughout the discussion, "ready-prepared" roast beef refers to beef that has been cooked (by the conventional, water bath or Alto-Shaam methods), chilled, sliced, packaged (with either gravy or carrageenan glaze) and reheated (either fresh or after frozen storage). CONV-1 and CONV-2, WB and AS refer to the conventional institution, hot-water bath and Alto-Shaam cooking method treatments respectively (Figure 1, page 30). GR and GLZ indicate gravy and carrageenan glaze, whereas FSH and FZN-S refer to the fresh and frozen-stored treatments, respectively (Figure 1).

Whole Roasts - Cooking Method

Data for objective measurements on roasts from each of the cooking methods are shown in Table 1. There were no significant differences in the weights of paired raw roasts. Although roast pairs were randomly assigned to treatments, CONV-1/WB roast pairs were lighter than CONV-2/AS pairs. Data for pH and for percentages of either extract, total moisture and thaw loss indicate that roasts cooked by all methods were similar.

The cooking times for roasts in minutes and in minutes per kilogram show significant differences attributable to cooking method (Table 1). CONV roasts cooked in the shortest time, followed by the AS roasts. Roasts cooked by the WB method required the longest cooking time, more than twice that of CONV treatments. Dinardo et al. (1982) also

Table 1. Means and F-values for Comparisons C1, C2 and C3[1] for objective data on roasts cooked by the conventional, water bath and Alto-Shaam methods.

Measurements	Cooking Method[2]				F-value		
	CONV-1	WB	CONV-2	AS	C1	C2	C3
Raw Roasts							
Weight (kg)[3]	3.68	3.88	3.94	3.93	3.60	0.01	12.05*
pH[4]	5.6	5.6	5.6	5.6	0.45	0.00	0.62
Ether Extract (%)[4]	3.5	3.5	3.6	3.8	0.07	1.17	0.21
Total Moisture (%)[4]	74.5	74.1	73.8	73.8	1.45	0.00	0.56
Thaw Loss (%)[3]	5.8	5.9	5.5	5.7	0.05	0.12	0.00
Cooked Roasts[3]							
Cooking Time (min)	138.1	338.0	151.3	194.9	1158.27**	72.14**	355.87**
Cooking Time (min/kg)	37.7	87.9	38.6	50.2	357.28**	55.57**	155.79**
Final Internal Temp (°C)	60.2	60.0	60.8	60.0	0.08	3.86	1.07
Cooking Losses (%)							
Total	17.7	16.5	18.5	17.7	2.61	3.49	0.48
Volatile	15.3	0.00	16.1	8.0	639.50**	244.39**	147.70**
Drip	2.4	16.5	2.4	9.7	592.64**	140.11**	54.33**
Chilling Drip (%)	1.9	1.0	1.7	1.2	22.64**	13.49*	6.82*
Total Cooking/ chilling Loss (%)	19.6	17.5	20.2	18.9	8.56*	15.52*	1.68
Dimensional Change (%)							
Length	-17.0	-8.5	-17.9	-11.4	36.43**	4.87	0.30
Width	- 0.2	-0.8	+ 1.0	- 3.0	0.02	0.84	0.19
Depth	+ 0.3	-0.1	0.0	- 2.7	0.02	0.62	0.28

[1]See Figure 2, page 32, for descriptions of comparisons.

[2]See Figure 1, page 30, for descriptions of treatment abbreviations.

[3]Values are the means of six determinations, one per replication.

[4]Values are the means of 12 determinations, two per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

reported that the cooking time for roasts cooked to 60° in a water bath (60°) was approximately twice as long as that for roasts cooked conventionally. In the present study, differences in cooking times are as expected since the oven temperature was 177° for CONV roasts and 107° for AS roasts, while the water temperature was 61° for WB treatments, similar to the desired final internal roast temperature (60°).

In the present study, CONV roasts required an average of 38.2 min/kg to cook to an internal temperature of 60°. Hunt et al. (1963) reported a similar cooking time (36.92 min/kg) for 4.5 kg top round roasts cooked conventionally (177°) to 60°.

Buck et al. (1979) cooked a variety of roast types (longissimus, semimembranosus, semitendinosus, biceps femoris and rectus femoris), ranging from 1 to 4 kg in weight, to 60° in a hot-water bath (60 to 61°) and reported an average cooking time of 178.48 min/kg. The cooking time observed for WB roasts in the current study was shorter (Table 1). A factor influencing cooking time may have been the long, flat (average depth at thickest point, 8.4 cm), tapered shape of the biceps femoris muscles used in the present study. The longer cooking times noted by Buck et al. (1979) may be related to the muscle types studied, their shape and dimensions - specifically thickness rather than weight. Other factors such as the initial roast temperature, the water bath volume, the amount of water circulation and

the method of cooling roasts may also have influenced cooking time.

Hunt et al. (1963) reported a cooking time of 75.3 min/kg for 4.5 kg top round roasts dry heat roasted at 107° to an internal temperature of 60°. Although the oven temperature was 107°, the cooking time for AS roasts (Table 1) was considerably shorter than that of Hunt et al. (1963). In addition to the influence of roast shape and size on cooking time, the high humidity generated in the Alto-shaam oven (Goodfellow and Brown, 1978) and the electrical thermal cables surrounding the cooking cavity may have contributed to the faster rate of heat penetration in AS roasts.

There were no significant differences in the final internal temperatures attained by roasts cooked by each method (Table 1); the average final internal temperature of all roasts was 60.25°.

The average percentage total cooking losses for roasts show no significant differences attributable to cooking method. Percentage total cooking losses for CONV roasts (Table 1) were similar to those noted by Shaffer et al. (1973) for beef top round roasts.

Buck et al. (1979) and Dinardo et al. (1982) reported significantly lower total cooking losses for a variety of roasts cooked to 60° by the water bath method than for comparable roasts cooked by a low temperature (94°) dry heat method. In addition, total cooking losses (10.71 %) for the water bath method were lower (Buck et al., 1979) than those

noted in the current experiment. Dinardo et al. (1982), using a similar water bath method, obtained cooking losses of 9% for roasts (1 to 3 kg) removed from the bath at an internal roast temperature of 60° and 13% to 15.5%, respectively, for roasts held 2 h and 4 h in the bath after reaching 60°. Proponents of commercial low-temperature water cooking of meat in vacuumized bags have obtained yields of up to 88% to 90% (Griffiths, 1976). The cooking losses (Table 1) determined in the present study may be due to the faster rate of heat penetration observed and to the flat, tapered shape (and therefore larger surface area for moisture loss) of the muscles studied. In addition, partially evacuated Cryovac® cooking bags (Ray et al., 1981) were used in the present experiment rather than the fully evacuated, heat stabilized nylon cooking bags employed by Buck et al. (1979) and Dinardo et al. (1982). In a project in which roasts were cooked to 68° by a hot-water bath method with hourly incremental water temperature increases from 68 to 80°, Ray et al. (1980) obtained total cooking losses of 20.2 and 22.1 percent for semitendinosus and semimembranosus roasts, respectively. Using a somewhat similar cooking method, Ray et al. (1981) reported a cooking loss of 18.4% in roasts cooked to 66°.

Marshall et al. (1960) showed that 4.5 kg top round roasts cooked to 60° by dry heat (107°) had cooking losses of approximately 10%. However, Buck et al. (1979) and Dinardo et al. (1982) obtained cooking losses of 13.8% and

16.0%, respectively, for roasts cooked to 60° by slow dry heat (94°). Vollmar et al. (1976) cooked beef top round roasts at 94° to 60° and obtained cooking losses of 18.0% for roasts cooked by dry heat and 20.8% for roasts cooked in oven film bags. Cooking losses of 19.3% have been reported for foil-wrapped biceps femoris roasts cooked at 93° to an internal temperature of 65° (Bramblett and Vail, 1964). In the present study, AS roasts had a 17.7% cooking loss. The moist low-temperature cooking environment generated in the Alto-Shaam oven may be comparable to the cooking environment in an oven film bag or a foil enclosure.

Both volatile and drip losses for roasts representing all cooking methods differed significantly (Table 1). As expected, for the CONV method, the largest portion of the total cooking loss was evaporative loss. In contrast, because they were completely enclosed in waterproof bags during cooking and cooling, WB roasts had no appreciable volatile losses. For roasts cooked by the AS method, volatile and drip losses were nearly similar (Table 1). Meat roasted slowly, in a partially or fully pressure-closed oven (79 to 107°), typically loses a larger percentage of its cooking loss as drip than meat roasted conventionally, indicating that water has been expressed from the meat but not evaporated (Schoman and Ball, 1961).

Roasts lost a small amount of drip during chilling (2°) to 3 ± 1° (Table 1). Percentage chilling drip was greater for roasts from CONV treatments than for comparable roasts

representing the WB and AS treatments. In addition, total cooking/chilling losses were significantly higher for CONV roasts than for WB and AS roasts.

Although no significant differences attributable to cooking method were observed for percentage width and depth change after cooking and chilling, roasts cooked by the CONV method demonstrated a greater ($P < 0.01$) percentage decrease in length than did comparable WB roasts (Table 1). In addition, roasts cooked by the CONV method shrank more in length than did AS roasts, although this difference is not significant. There was no difference in the change in length between WB and AS roasts. Dinardo et al. (1982) reported that roasts cooked to 60° in a hot-water bath (60°) gave greater cooked yields than comparable roasts cooked to 60° by dry heat (94°). Ray et al. (1980) cooked roasts in Cryovac® bags to 68° in a water bath by gradually increasing the water temperature from 68 to 80° over the cooking period. For semitendinosus and semimembranosus roasts respectively, 21.5% and 28.4% length decreases, 7.6% and 9.6% width decreases and 4.7% and 9.5% depth increases were noted (Ray et al., 1980). These values (Ray et al., 1980) are considerably higher than the dimensional changes observed in the present study (Table 1).

Packages for Individual Service

Cooking Method

Fresh samples

Table 2 summarizes means and F-values for subjective and objective data on FSH "ready-prepared" roast beef cooked by the CONV and WB methods. No significant differences between CONV and WB treatments were observed in slice evaluation scores for overall appearance, color, degree of doneness and uniformity of doneness. However, samples from the WB treatment were scored significantly higher for grain than comparable CONV samples, indicating that WB beef slices had a finer, more attractive grain.

Buck et al. (1979) and Dinardo et al. (1982) noted that roasts cooked to rare by the water bath method were more uniform in cross-sectional doneness than roasts cooked by dry heat, which displayed a definite "ring effect". Results obtained by Dinardo et al. (1982) were substantiated by Gardner color values. In the present study, differences in uniformity of doneness of beef due to cooking method, although evident in the freshly sliced roast beef, were eliminated by reheating the beef to the well-done stage.

Trained panelists (Table 2) detected no significant effects of cooking method on the desirability of aroma and flavor, intensity of beefy aroma and flavor, intensity of WOA and WOF, juiciness and overall acceptability of FSH "ready-prepared" roast beef. Dinardo et al. (1982) also found no flavor differences between roast beef cooked in a

Table 2. Means and F-values for Comparison C1[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional and water bath methods - fresh.

Measurements	Cooking Method[2] CONV-1	WB	F-value
Subjective			
Slice evaluation[3]			
Overall appearance	3.3	3.6	2.53
Color	3.5	3.5	0.05
Grain	3.4	3.9	13.85**
Degree of doneness	3.2	3.6	2.39
Uniformity of doneness	3.9	3.8	2.06
Trained taste panel[4]			
Desirability of - aroma	5.3	5.3	0.62
- flavor	5.0	5.2	1.21
Intensity of beefy - aroma	5.0	5.1	2.00
- flavor	5.0	5.1	0.10
Intensity of warmed-over - aroma	6.4	6.5	1.11
- flavor	6.5	6.6	0.61
Tenderness	4.6	5.2	6.98*
Juiciness	3.5	3.8	0.39
Overall acceptability	4.8	5.0	1.19
Objective			
TBA value (mg malonaldehyde/kg)[5]	1.8	1.7	2.03
Shear force (kg/g)[5]	0.26	0.25	1.64
Water holding capacity[6]	0.51	0.54	0.68

[1]See Figure 2, page 32, for description of comparison.

[2]See Figure 1, page 30, for descriptions of treatment abbreviations.

[3]Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4]Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5]Values are the means of 24 determinations, two per package addition per replication.

[6]Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

water bath and samples cooked by dry heat. However, WB FSH samples in the present study received significantly higher tenderness scores than comparable CONV samples.

TBA and WHC values for CONV FSH and WB FSH treatments did not differ significantly and therefore substantiate sensory scores for intensity of WOA/WOF and for juiciness, respectively (Table 2). Shear force data for CONV and WB treatments were similar; however, these data do not support judges' tenderness scores.

Summarized in Table 3 are means and F-values for subjective and objective data on FSH "ready-prepared" roast beef cooked by the CONV and AS methods. There were no significant differences in the overall appearance, color, grain, degree of doneness and uniformity of doneness of beef slices attributable to cooking method.

Taste panelists detected no treatment differences for desirability of aroma and flavor and for intensity of WOA and WOF for FSH "ready-prepared" roast beef. Panelists scored the aroma of AS FSH samples as more ($P < 0.01$) beefy than that of comparable CONV samples; however this difference was not noted in scores for intensity of beefy flavor. There were no significant differences in tenderness, juiciness and overall acceptability scores between CONV and AS treatments. Nielsen and Hall (1965) also reported no difference in the tenderness of rump roasts dry-heat roasted to 71° at 163° and 107°.

TBA and WHC values for CONV and AS samples did not

Table 3. Means and F-values for Comparison C2[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional and Alto-Shaam methods - fresh.

Measurements		Cooking Method[2] CONV-2	AS	F-value
Subjective				
Slice evaluation[3]				
Overall appearance		3.3	3.3	0.01
Color		3.5	3.5	0.00
Grain		3.3	3.5	0.33
Degree of doneness		3.1	3.0	0.20
Uniformity of doneness		3.7	4.1	2.66
Trained taste panel[4]				
Desirability of	- aroma	5.2	5.4	1.42
	- flavor	5.1	5.1	0.40
Intensity of beefy	- aroma	4.8	5.1	29.15**
	- flavor	5.1	5.0	0.86
Intensity of warmed-over	- aroma	6.5	6.4	0.54
	- flavor	6.4	6.5	0.06
Tenderness		4.7	4.7	0.03
Juiciness		3.5	3.2	2.25
Overall acceptability		4.9	4.9	0.01
Objective				
TBA value (mg malonaldehyde/kg)[5]		1.3	1.4	0.19
Shear force (kg/g)[5]		0.25	0.27	5.87
Water holding capacity[6]		0.53	0.54	0.09

[1]See Figure 2, page 32, for description of comparison.

[2]See Figure 1, page 30, for descriptions of treatment abbreviations.

[3]Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4]Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5]Values are the means of 24 determinations, three per package addition per replication.

[6]Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

differ significantly; these data agree with sensory scores for intensity of WOA/WOF and for juiciness, respectively (Table 3). Shear force values for CONV and AS treatments were similar and also support tenderness scores. Hunt et al. (1963) found no significant difference in Warner Bratzler shear values between beef top round roasts dry-heat roasted to 60° at 177° versus 107°.

Means and F-values for data on FSH "ready-prepared" roast beef cooked by the WB and AS methods are presented in Table 4. No significant differences attributable to cooking method were found for each of the characteristics evaluated. Tenderness scores, however, tended to be higher for WB FSH samples than for comparable AS samples, although this difference is not significant. Kramer shear force values also tended to be lower for WB than for AS samples.

Buck et al. (1979) found that roasts cooked to 60° by the water bath method received higher tenderness scores, demonstrated lower Warner Bratzler shear force values and had higher press fluid values than comparable beef cooked by a slow dry-heat method. Dinardo et al. (1982) also reported lower Warner Bratzler shear values and higher tenderness scores for beef cooked to rare by the water bath method than for beef cooked to 60° at 94°. In the present study, however, effects of WB cooking on the tenderness and moistness of FSH "ready-prepared" roast beef may have been minimized by reheating the thin (4 mm) beef slices.

Generally, scores for appearance characteristics of FSH

Table 4. Means and F-values for Comparison C3[1] for subjective and objective data on "ready-prepared" roast beef cooked by the water bath and Alto-Shaam methods - fresh.

Measurements	Cooking Method[2] WB	AS	F-value
Subjective			
Slice evaluation[3]			
Overall appearance	3.6	3.3	1.36
Color	3.5	3.5	0.03
Grain	3.9	3.5	0.65
Degree of doneness	3.6	3.0	3.48
Uniformity of doneness	3.8	4.1	3.99
Trained taste panel[4]			
Desirability of - aroma	5.3	5.4	0.06
- flavor	5.2	5.1	0.75
Intensity of beefy - aroma	5.1	5.1	2.05
- flavor	5.1	5.0	0.39
Intensity of warmed-over - aroma	6.5	6.4	2.36
- flavor	6.6	6.5	3.75
Tenderness	5.2	4.7	4.00
Juiciness	3.8	3.2	1.18
Overall acceptability	5.0	4.9	0.99
Objective			
TBA value (mg malonaldehyde/kg)[5]	1.7	1.4	1.19
Shear force (kg/g)[5]	0.25	0.27	5.44
Water holding capacity[6]	0.54	0.54	0.18

[1] See Figure 2, page 32, for description of comparison.

[2] See Figure 1, page 30, for descriptions of treatment abbreviations.

[3] Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4] Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5] Values are the means of 24 determinations, two per package addition per replication.

[6] Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

"ready-prepared" roast beef indicate that beef samples representing each of the cooking methods were comparable and were judged as desirable by trained judges (Tables 2 to 4). Cremer and Chipley (1980) also reported good scores for the appearance, color and texture of beef bottom round roasts cooked to about 75°, chilled (approximately 15 h), sliced and reheated (to about 63°).

Juiciness scores and WHC values (Tables 2 to 4) for FSH "ready-prepared" roast beef did not differ among cooking method treatments as might be suggested by data for cooking/ chilling losses (Table 1). The reheating process may have eliminated cooking method effects on sample juiciness and moisture content. Furthermore, even in studies with freshly roasted beef, other researchers (Buck et al., 1979) have found the correlation between cooking losses and juiciness scores to be low.

For beef slices from all cooking methods, TBA values were low compared to that of the WOA/WOF ground beef anchor[1] which was established as being equivalent to a score of 4 (moderate) on the seven-point intensity scale. TBA values for FSH beef samples substantiate WOA/WOF sensory scores (Tables 2 to 4) which indicate that WOA and WOF were very slight to not detectable in beef samples prepared by each of the cooking methods.

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[1]Mean TBA value for WOA/WOF anchor during evaluations of FSH treatments, 5.3 ± 0.8.

Published information on TBA values of meat which has been roasted, chilled, sliced and immediately reheated is limited. Baldwin and Korschgen (1968) reported TBA values of approximately 0.25 to 0.45 for meat roasted, chilled, sliced (1.75 cm thick) and broiled. Johnston and Baldwin (1980) obtained a TBA value of 0.386 for freshly roasted beef. However, these workers (Baldwin and Korschgen, 1968; and Johnston and Baldwin, 1980) used an extraction method for the determination of malonaldehyde, which gives TBA values of about one-half the magnitude of values obtained with the distillation method employed in the present study. Taste panelists perceived no oxidized flavor in freshly cooked beef steaks having a TBA value of 1.0 (Haymon et al., 1976).

In general, data for CONV, WB and AS samples of FSH "ready-prepared" roast beef were similar and indicate that beef slices cooked by each of the three methods were acceptable to very acceptable with respect to most quality characteristics evaluated. In similar studies, other researchers (Baldwin and Korschgen, 1968; Korschgen et al., 1970; and Cremer and Chipley, 1980) have also found cooked, sliced, freshly reheated beef to be of desirable quality.

Fresh and Frozen-Stored Samples

Table 5 summarizes means and F-values for subjective and objective data on FSH and FZN-S "ready-prepared" roast beef cooked by the CONV, WB and AS methods. No significant effects attributable to frozen storage were noted for the

Table 5. Means and F-values for Comparisons C15, C16 and C17[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional, water bath and Alto-Shaam methods - fresh and frozen-stored[2].

		C15			C16			C17	
	CONV-1 & CONV-2			WB			AS		
Measurements	FSH	FZN-S	F-value	FSH	FZN-S	F-value	FSH	FZN-S	F-value
Subjective									
Slice evaluation[3]									
Overall appearance	3.3	3.2	2.74	3.6	3.1	11.81**	3.3	3.1	1.93
Color	3.5	3.3	2.77	3.5	3.2	2.72	3.5	3.3	0.68
Grain	3.4	3.1	8.00**	3.9	3.1	43.04**	3.5	2.9	20.07**
Degree of doneness	3.1	3.0	0.93	3.6	3.3	4.54*	3.0	2.8	6.54*
Uniformity of doneness	3.8	3.8	0.17	3.8	3.9	0.28	4.1	3.8	2.35
Trained taste panel[4]									
Desirability of - aroma	5.3	5.0	9.46**	5.3	5.0	9.35**	5.4	4.9	17.90**
- flavor	5.0	4.9	3.97	5.2	4.9	7.15**	5.1	4.8	7.05*
Intensity of beefy - aroma	4.9	4.5	38.89**	5.1	4.6	30.18**	5.1	4.4	60.46**
- flavor	5.1	4.6	19.97**	5.1	4.8	6.53*	5.0	4.6	9.86**
Intensity of warmed-over - aroma	6.5	6.5	1.98	6.5	6.6	2.32	6.4	6.5	0.01
- flavor	6.5	6.6	4.94*	6.6	6.7	2.18	6.5	6.6	2.54
Tenderness	4.7	4.6	0.93	5.2	4.8	10.08**	4.7	4.4	4.58*
Juiciness	3.5	3.5	0.00	3.8	3.7	0.28	3.2	3.5	1.84
Overall acceptability	4.8	4.5	9.11**	5.0	4.7	6.34*	4.9	4.5	5.85*
Objective									
TBA value (mg malonaldehyde/kg)[5]	1.6	1.6	0.01	1.7	1.4	1.39	1.4	1.4	0.01
Shear force (kg/g)[5]	0.26	0.27	2.43	0.25	0.24	0.43	0.27	0.26	0.30
Water holding capacity[6]	0.52	0.41	37.81**	0.54	0.42	18.84**	0.54	0.42	21.19**

[1]See Figure 2, page 32, for descriptions of comparisons.
[2]See Figure 1, page 30, for descriptions of treatment abbreviations.
[3]Maximum score, 5. Values are the means of 96 (CONV-1 and -2) or 48 (WB or AS) judgements, one per package addition per replication by each of four panelists.
[4]Maximum score, 7. Values are the means of 192 (CONV-1 and -2) or 96 (WB or AS) judgements, one per package addition per replication by each of eight panelists.
[5]Values are the means of 48 (CONV-1 and -2) or 24 (WB or AS) determinations, two per package addition per replication.
[6]Values are the means of 72 (CONV-1 and -2) or 36 (WB or AS) determinations, three per package addition per replication.
* Significant at $P < 0.05$
** Significant at $P < 0.01$

overall appearance of CONV and AS samples. However, WB FSH sample appearance was scored significantly higher than comparable FZN-S sample appearance. For color and uniformity of doneness, FSH and FZN-S roast beef slices representing each cooking method received similar scores. No off-color was observed in FSH samples, though judges occasionally noted an iridescence on the surface of some FZN-S beef slices from all cooking methods.

Freezing and storage altered ($P < 0.01$) the grain of "ready-prepared" roast beef cooked by each method (Table 5). The grain of FSH samples was finer and more attractive than that of comparable FZN-S samples. Panelists detected no significant differences in the degree of doneness of CONV beef slices attributable to frozen storage. Although significant differences in degree of doneness were detected between FSH and FZN-S beef slices from the WB and AS cooking methods, for practical purposes the differences are negligible. Judges indicated that all meat slices appeared dry and somewhat overdone, particularly around the edges. The use of thin slices, combined with reheating the meat to 80°, probably accounts for the dryness of meat samples.

For desirability of aroma, FSH "ready-prepared" roast beef samples cooked by each technique were scored higher ($P < 0.01$) than comparable FZN-S treatments. CONV FSH and CONV FZN-S samples received similar scores for flavor desirability; WB FSH and AS FSH treatments were rated

significantly higher than comparable FZN-S samples for this attribute. In somewhat similar studies, previous workers have also noted decreases in aroma (Baldwin and Korschgen, 1968; and Korschgen et al., 1970) and flavor (Bramblett et al., 1965; Baldwin and Korschgen, 1968; and Korschgen et al., 1970) scores for sliced cooked beef due to freezing and storage.

For samples representing each cooking method, the intensity of beefy aroma and flavor decreased significantly with freezing and storage (Table 5). In addition, panelists frequently described the aroma and flavor of FSH samples as "beefy". There were no significant effects due to frozen storage on the intensity of WOA in beef slices from each cooking procedure. Although judges detected slightly more WOF in CONV FSH samples than in comparable CONV FZN-S samples ($P < 0.05$), for practical purposes this difference is small. Beef samples cooked by both the WB and AS methods had WOF scores which were similar for both storage treatments. However, judges more often described FSH samples as having a characteristic "fresh" aroma and flavor.

Tenderness scores for the CONV FSH and CONV FZN-S treatments were similar (Table 5). WB FSH and AS FSH samples were rated significantly higher in tenderness than comparable FZN-S samples. Korschgen et al. (1970) evaluated foil-wrapped beef round roasts that were cooked at 95° to 71°, sliced (0.65 cm thick), packaged in foil trays and reheated. They (Korschgen et al., 1970) reported

significantly higher tenderness scores for fresh samples than for samples stored frozen (three months). In contrast, Bramblett et al. (1965) cooked foil-wrapped beef round roasts (93°) to 65° and noted no appreciable decrease in the tenderness of the cooked beef slices (3 cm thick) after three months frozen storage. No difference in the tenderness of freshly reheated beef slices (1.75 cm thick) from chuck roll roasts cooked (149°) to 43° and comparable frozen-stored (one month) reheated beef slices was found (Baldwin and Korschgen, 1968).

Juiciness scores (Table 5) for samples from each cooking method were similar for both FSH and FZN-S treatments. Baldwin and Korschgen (1968) also obtained similar scores for the juiciness of reheated fresh and short frozen-stored cooked beef slices. In contrast, Korschgen et al. (1970) reported significantly higher juiciness scores for sliced cooked beef in foil trays reheated fresh than for comparable beef slices reheated after three months frozen storage. However as noted earlier, processing techniques (cooking method and temperature, final roast internal temperature, slice thickness, package addition, reheating method and internal temperature of meat slices attained in reheating) employed in these studies (Baldwin and Korschgen, 1968; and Korschgen et al., 1970) differed from those used in the present experiment.

Juiciness was the only attribute scored below 4 on the seven-point scale. This score indicates that samples were

slightly dry to neither juicy nor dry (Table 5). Others (Korschgen et al., 1970; and Baldwin and Korschgen, 1968) have reported higher juiciness scores for fresh and frozen-stored cooked sliced beef than those obtained in the current study. In the present experiment, the dryness of meat slices may be due to the use of thin slices and to the internal temperature meat slices attained in reheating.

Overall acceptability scores for samples representing each cooking method were significantly higher for FSH than for FZN-S treatments. However, for "ready-prepared" roast beef representing each storage treatment, overall acceptability scores were good (4.5 to 5 on a seven-point scale).

For samples representing each cooking method, there were no significant differences in TBA values attributable to freezing and storage. These data generally support taste panel scores for WOA and WOF (Table 5). Baldwin and Korschgen (1968) reported no significant differences in the TBA values of control samples and frozen-stored cooked sliced beef. In another study, the TBA values reported for freshly cooked ground beef patties and for cooked, frozen-stored reheated patties were also similar (Bowers and Engler, 1975). Haymon et al. (1976) noted a slight increase in the TBA value of frozen-stored (four weeks) cooked beef steak over that of a fresh product. In contrast, Chang et al. (1961) found lower TBA values in meat which had been cooked, frozen and thawed. The general handling procedures

(roasting, overnight chilling, thinly slicing and reheating) applied to both FSH and FZN-S treatments probably account for the slight amount of oxidation indicated by TBA values and for the slight amount of WOA and WOF detected by panelists in the present study.

Shear values did not differ significantly between FSH and FZN-S treatments representing each cooking method. These data support sensory scores for the tenderness of CONV and AS samples but do not agree with sensory data for the tenderness of WB samples. Factors such as softness, juiciness and desirability of flavor may have influenced judges' perception of the tenderness of WB samples. In investigating the quality of frozen cooked beef, other workers (Dahlinger and Lewis, 1954) have also reported a lack of agreement between subjective and instrumental measures of tenderness.

For all cooking methods, WHC values decreased significantly with freezing and storage (Table 5). The decrease in the moistness of beef slices may have been due to evaporation of moisture during freezing and frozen storage. However, for each cooking procedure, taste panelists did not detect a difference in the juiciness of FSH and FZN-S samples. Buck et al. (1979) found that press fluid values did not support taste panel scores for the juiciness of freshly cooked beef. In the present study, WHC values were low (Table 5) compared to those obtained in previous work for freshly cooked beef (Hawrysh and Berg, 1976; Hawrysh and Berg, 1979; and Hawrysh et al., 1979). Therefore, beef

dryness was probably due to the reheating process. For both FSH and FZN-S treatments, juiciness scores were relatively low (Table 5), indicative of slightly dry to neither juicy nor dry meat. Judges often commented that samples were dry.

Frozen-Stored Samples

Table 6 summarizes means and F-values for subjective and objective data on FZN-S "ready-prepared" roast beef cooked by the CONV and WB methods. No significant differences between CONV and WB treatments were found in the data for overall appearance, color, grain, degree of doneness and uniformity of doneness of beef slices.

Trained judges detected no significant effects of either the CONV or WB cooking methods on the desirability of aroma and flavor, intensity of beefy aroma and flavor and intensity of WOA of FZN-S "ready-prepared" roast beef. However, judges noted that CONV FZN-S samples had significantly more WOF than comparable WB samples, although for practical purposes this difference is negligible. Previous research (Zipser and Watts, 1961; Huang and Greene, 1978; and Sato et al., 1973) has shown that browning reactions which occur during slow cooking of beef to high temperatures result in the production of antioxidant compounds in the meat. In the present study, some antioxidant compounds may have been produced in roasts cooked by the long, slow water bath method. However, cooking the meat to rare rather than well-done probably limited the extent to which WOF-retarding substances were formed. For

Table 6. Means and F-values for Comparison C1[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional and water bath methods - frozen-stored.

Measurements		Cooking Method[2]		
		CONV-1	WB	F-value
Subjective				
Slice evaluation[3]				
Overall appearance		3.2	3.1	0.93
Color		3.3	3.2	0.11
Grain		3.1	3.1	0.52
Degree of doneness		3.2	3.3	0.10
Uniformity of doneness		3.7	3.9	0.56
Trained taste panel[4]				
Desirability of	- aroma	5.0	5.0	1.22
	- flavor	4.8	4.9	2.03
Intensity of beefy	- aroma	4.4	4.6	3.12
	- flavor	4.5	4.8	2.68
Intensity of warmed-over	- aroma	6.5	6.6	0.88
	- flavor	6.5	6.7	23.06**
Tenderness		4.5	4.8	22.42**
Juiciness		3.4	3.7	16.56**
Overall acceptability		4.3	4.7	11.05*
Objective				
TBA value (mg malonaldehyde/kg)[5]		1.8	1.4	2.82
Shear force (kg/g)[5]		0.28	0.24	12.41*
Water holding capacity[6]		0.40	0.42	0.40

[1] See Figure 2, page 32, for description of comparison.

[2] See Figure 1, page 30, for descriptions of treatment abbreviations.

[3] Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4] Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5] Values are the means of 24 determinations, two per package addition per replication.

[6] Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

tenderness, juiciness and overall acceptability, WB FZN-S samples received significantly higher scores than did comparable CONV FZN-S samples.

TBA values for CONV FZN-S and WB FZN-S treatments did not differ significantly and therefore substantiate sensory scores for intensity of WOA. TBA data do not support sensory scores for WOF intensity. The small difference in WOF between CONV and WB treatments was not reflected in the chemical determination of lipid oxidation (TBA value).

Kramer shear force values were significantly lower for WB FZN-S samples than for comparable CONV FZN-S samples. These data agree with taste panel scores for tenderness (Table 6) which show that WB samples were more tender than CONV samples.

WHC values for FZN-S "ready-prepared" roast beef did not differ significantly for the CONV and WB cooking techniques. These data do not substantiate taste panel juiciness scores. Others (Buck et al., 1979) have found that press fluid values and sensory scores for juiciness do not always support each other.

Summarized in Table 7 are means and F-values for subjective and objective data on FZN-S "ready-prepared" roast beef cooked by the CONV and AS methods. There were no significant differences in the scores for overall appearance, color, grain, degree of doneness and uniformity of doneness of beef slices from CONV FZN-S and AS FZN-S treatments.

Although judges scored the desirability of aroma and

Table 7. Means and F-values for Comparison C2[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional and Alto-Shaam methods - frozen-stored.

Measurements	Cooking method[2] CONV-2	AS	F-value
Subjective			
Slice evaluation[3]			
Overall appearance	3.1	3.1	0.00
Color	3.2	3.3	0.21
Grain	3.1	2.9	1.62
Degree of doneness	2.9	2.8	0.07
Uniformity of doneness	3.8	3.8	0.02
Trained taste panel[4]			
Desirability of - aroma	5.1	4.9	7.34*
- flavor	4.9	4.8	28.78**
Intensity of beefy - aroma	4.6	4.4	10.21*
- flavor	4.7	4.6	1.93
Intensity of warmed-over - aroma	6.6	6.5	4.18
- flavor	6.6	6.6	0.88
Tenderness	4.7	4.4	5.04
Juiciness	3.6	3.5	0.65
Overall acceptability	4.7	4.5	12.46*
Objective			
TBA value (mg malonaldehyde/kg)[5]	1.4	1.4	0.25
Shear force (kg/g)[5]	0.27	0.26	1.46
Water holding capacity[6]	0.41	0.42	0.00

[1] See Figure 2, page 32, for description of comparison.

[2] See Figure 1, page 30, for descriptions of treatment abbreviations.

[3] Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4] Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5] Values are the means of 24 determinations, two per package addition per replication.

[6] Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

flavor, intensity of beefy aroma and overall acceptability of CONV FZN-S samples higher than those of comparable AS FZN-S samples, these differences are small and may not be of practical significance. Though the difference is not significant, CONV FZN-S samples tended to be rated higher for tenderness than comparable AS FZN-S samples. Judges detected no differences in the intensity of beefy flavor, intensity of WOA and WOF and juiciness of FZN-S "ready-prepared" roast beef due to the CONV and AS cooking procedures.

TBA, shear force and WHC values for CONV FZN-S and AS FZN-S samples did not differ significantly. These data agree with sensory scores for intensity of WOA/WOF, tenderness and juiciness, respectively.

Means and F-values for data on FZN-S "ready-prepared" roast beef cooked by the WB and AS methods are presented in Table 8. No significant differences between the WB and AS cooking techniques were observed for the overall appearance, color, grain, degree of doneness and uniformity of doneness of FZN-S beef slices.

Taste panelists rated the desirability of aroma, intensity of beefy aroma and flavor, intensity of WOF, tenderness, juiciness and overall acceptability of WB FZN-S beef slices significantly higher than those of comparable AS FZN-S samples. However, the aroma and flavor differences are small. For FZN-S beef, there were no differences between the WB and AS cooking procedures for

Table 8. Means and F-values for Comparison C3[1] for subjective and objective data on "ready-prepared" roast beef cooked by the water bath and Alto-Shaam methods - frozen-stored.

Measurements		Cooking Method[2] WB	AS	F-value
Subjective				
Slice evaluation[3]				
Overall appearance		3.1	3.1	0.08
Color		3.2	3.3	0.16
Grain		3.1	2.9	0.19
Degree of doneness		3.3	2.8	0.19
Uniformity of doneness		3.9	3.8	0.07
Trained taste panel[4]				
Desirability of	- aroma	5.0	4.9	28.45**
	- flavor	4.9	4.8	5.56
Intensity of beefy	- aroma	4.6	4.4	12.34*
	- flavor	4.8	4.6	6.30*
Intensity of warmed-over	- aroma	6.6	6.5	2.87
	- flavor	6.7	6.6	7.16*
Tenderness		4.8	4.4	22.33**
Juiciness		3.7	3.5	8.39*
Overall acceptability		4.7	4.5	19.78**
Objective				
TBA value (mg malonaldehyde/kg)[5]		1.4	1.4	2.91
Shear force (kg/g)[5]		0.24	0.26	4.96
Water holding capacity[6]		0.42	0.42	0.08

[1] See Figure 2, page 32, for description of comparison.

[2] See Figure 1, page 30, for descriptions of treatment abbreviations.

[3] Maximum score, 5. Values are the means of 48 judgements, one per package addition per replication by each of four panelists.

[4] Maximum score, 7. Values are the means of 96 judgements, one per package addition per replication by each of eight panelists.

[5] Values are the means of 24 determinations, two per package addition per replication.

[6] Values are the means of 36 determinations, three per package addition per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

desirability of flavor and intensity of WOA. No significant differences between WB FZN-S and AS FZN-S treatments were observed for TBA, shear force and WHC values. The high F-value for shear force tends to support tenderness scores.

For each of the cooking method treatments, the TBA value was low compared to that of the WOA/WOF anchor[1]. TBA values substantiate panelists' scores for the FZN-S treatment (Tables 6 to 8) which indicate that WOA and WOF were very slight to not detectable in samples prepared by all cooking methods.

Baldwin and Korschgen (1968) found that TBA values for sliced beef cooked to 43° were low (less than 1.0) even after one year of frozen storage. However, the extraction method used by Baldwin and Korschgen (1968) gives lower TBA values than the distillation method employed in the present study. Moreover, these workers (Baldwin and Korschgen, 1968) found no significant correlation between sensory and TBA data for meat frozen and stored 1 day to 12 months. In contrast, Jakobsson and Bengtsson (1972), in a project with sliced beef (1.5 cm thick) fried to the well-done stage and stored either chilled (1 to 21 days) or frozen (two months), found good correlation between TBA values and off-flavor scores. Although these workers (Jakobsson and Bengtsson, 1972) did not measure the TBA value for fresh reference

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[1]Mean TBA value for WOA/WOF anchor during evaluations of FZN-S treatments, 5.2 ± 1.15.

samples, their TBA values were low for the frozen product compared to the product which was stored chilled. Buttkus (1976) noted that during storage at -20°, malonaldehyde combines quickly with the ϵ-amino groups of myosin, rendering TBA values lower than those of meat stored chilled.

Previous research suggests that the relationship between TBA values and sensory scores for WOA/WOF is variable. Tarladgis et al. (1960) concluded that TBA values of 0.5 to 1.0 are in the range for WOA detection in meat. In a recent study with consumer panelists, Greene and Cumuze (1981) found that the TBA value range in which oxidized flavor was first detected was 0.6 to 2.0.

Data from a number of studies (Chang et al., 1961; Bowers and Engler, 1975; Younathan et al., 1980; Haymon et al., 1976; and Huang and Greene, 1978) show that there is both variability and inconsistency in the relationship between WOF detection by trained panelists and TBA values. Because the manner in which chemical reaction products contributing to the TBA value are produced and recombined in food systems is extremely variable (Dawson and Schierholz, 1976), TBA values may not be predictable and may not be reliable indicators of the extent to which WOA and WOF will be detected subjectively.

Huang and Greene (1978) suggested that a TBRA (TBA retarding activity) index be employed when discussing data in terms of relative treatment effects in order to eliminate discrepancies arising from the use of absolute TBA

values as the only measure of autoxidation.

In general, data presented in Tables 6 to 8 indicate that for most characteristics studied, FZN-S "ready-prepared" roast beef cooked by each of the three methods was acceptable to very acceptable, particularly with regard to the degree of WOA and WOF intensity. Using various combinations of low heat, dry or moist conditions and/or rare stages of final doneness for beef, other researchers (Bramblett et al., 1965; Baldwin and Korschgen, 1968; Korschgen et al., 1970; and Rappole, 1972) have also found the quality of the sliced, frozen-stored, reheated product to be acceptable. However, in these reports (Bramblett et al., 1965; Baldwin and Korschgen, 1968; Korschgen et al., 1970; and Rappole, 1972) aspects of the experimental procedure, including slice thickness, package addition and reheating methods as well as other processing techniques for "ready-prepared" roast beef, differed and varied considerably from those used in the present study.

Package Addition

Temperatures and Reheating Times

Just prior to LCO_2 freezing, the average center temperature of roast beef packaged in GR in Traytite® packages (IND) was 17.2° (range, 15.6° to 19.0°) and that of comparable IND GLZ samples was 18.6° (range, 15.8° to 20.6°). Immediately after LCO_2 freezing, the center temperature of both IND GR and IND GLZ samples was below 0°. The average temperature of GR samples was -0.9° (range, -8.8° to -0.3°)

while that of IND GLZ samples was -2.0° (range, -8.8° to -0.3°). These data are the means of 18 measurements, three per replication.

GR FSH samples required an average reheating time of 9.9 ± 1.6 min to attain a final center temperature of 80°; GLZ FSH beef slices reached 80° in an average of 6.9 ± 1.0 min. GR FZN-S samples required a mean reheating time of 20.4 ± 2.7 min to achieve a final center temperature of 80°; GLZ FZN-S beef slices reached 80° in an average time of 11.8 ± 1.1 min. These data are the means of 24 measurements, one per cooking method treatment per replication. The volume and depth of gravy in GR packages probably accounts for the long reheating time required for GR beef.

Fresh Samples

Data for the effects of package addition on the palatability of FSH "ready-prepared" roast beef are presented in Table 9. Scores for overall appearance, color, grain and degree of doneness of beef slices show no significant differences attributable to type of package addition. FSH samples packaged in GLZ were rated higher ($P < 0.05$) for uniformity of doneness than comparable samples packaged in GR. Judges also commented that GR FSH samples sometimes had an uneven color.

Trained panelists indicated that type of package addition had no significant effect on the desirability of aroma and flavor of FSH "ready-prepared" roast beef. However, GR FSH "ready-prepared" roast beef slices had a

Table 9. Means and F-values for subjective and objective data on "ready-prepared" roast beef packaged in gravy and carrageenan glaze - fresh.

Measurements		Package Addition[1] GR	GLZ	F-value
Subjective				
Slice evaluation[2]				
Overall appearance		3.3	3.4	0.29
Color		3.4	3.5	0.91
Grain		3.6	3.5	0.37
Degree of doneness		3.1	3.3	1.08
Uniformity of doneness		3.7	4.0	4.74*
Trained taste panel[3]				
Desirability of	- aroma	5.3	5.3	0.41
	- flavor	5.1	5.1	0.64
Intensity of beefy	- aroma	5.1	5.0	4.69*
	- flavor	5.2	4.9	4.57*
Intensity of warmed-over	- aroma	6.6	6.3	10.96**
	- flavor	6.6	6.3	24.06**
Tenderness		4.8	4.8	0.00
Juiciness		3.8	3.2	14.87**
Overall acceptability		5.0	4.8	4.01
Objective				
TBA value (mg malonaldehyde/kg)[4]		1.4	1.7	4.33
Shear force (kg/g)[4]		0.25	0.27	4.26
Water holding capacity[5]		0.51	0.55	4.82*

[1] See Figure 1, page 30, for descriptions of treatment abbreviations.

[2] Maximum score, 5. Values are the means of 96 judgements, one per cooking method per replication by each of four panelists.

[3] Maximum score, 7. Values are the means of 192 judgements, one per cooking method per replication by each of eight panelists.

[4] Values are the means of 48 determinations, two per cooking method per replication.

[5] Values are the means of 72 determinations, three per cooking method per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

more intense ($P < 0.05$) beefy aroma and flavor than GLZ FSH samples, although the aroma difference is slight. The aroma and flavor of GR FSH treatments were characterized as "bouillon-like" and occasionally as "oniony", "peppery", "salty", "spicy" and "burnt". These characteristics in GR FSH samples may have influenced beefy intensity. Judges often described the GLZ FSH beef slices as "beefy" and also indicated that comparable GLZ samples were "fresh", which may imply a more natural beefy aroma and flavor. Panelists also occasionally described the flavor of GLZ FSH samples as "weak". The data show that GLZ FSH treatments had greater ($P < 0.01$) WOA and WOF than comparable GR samples, however the difference is small and therefore may not have practical significance.

There was no significant difference in tenderness between GR FSH and GLZ FSH treatments. Korschgen et al. (1970) noted no tenderness difference between freshly reheated roast beef slices packaged in foil trays with and without gravy.

GR FSH samples were juicier ($P < 0.01$) than comparable GLZ FSH samples (Table 9). Korschgen et al. (1970) found freshly cooked reheated beef slices with gravy to be less juicy than comparable samples packaged without gravy. However, these roasts (Korschgen et al., 1970) were cooked to 71°, the slices were 0.65 cm thick and the handling methods for roasts prior to slicing as well as the extent

to which the meat was reheated were not indicated.

Panelists judged the overall acceptability of FSH "ready-prepared" roast beef packaged with either GR or GLZ to be similar. Korschgen et al. (1970) reported higher general acceptability scores for fresh roast beef slices reheated without gravy than for comparable samples reheated with gravy.

TBA values for GLZ FSH treatments, although not significantly higher than those determined for GR FSH treatments, tend to support sensory scores obtained for intensity of WOA and WOF (Table 9) which show that GLZ FSH samples had more WOA and WOF than FSH samples treated with GR. Shear force values for FSH samples packaged with either GR or GLZ were similar. These data substantiate taste panel scores for the tenderness of FSH beef.

The WHC value for GLZ FSH "ready-prepared" roast beef was higher ($P < 0.05$) than that obtained for comparable GR slices. After removal from the oven, GR FSH samples remained above a temperature of 75° longer (about 5 min) than GLZ FSH samples; thus, GR FSH samples may have lost more moisture during reheating. The WHC value for GLZ FSH treatments may also be related to the ability of carrageenan to form a tight water-trapping gel complex (Sanderson, 1981; Sharma, 1981; and Marine Colloids Division FMC Corp., 1981).

WHC data for FSH samples do not support corresponding taste panel scores for juiciness. Several factors may contribute to this lack of agreement between subjective and

objective data. Panelists evaluated the initial juiciness (impression after five chews) of samples, while WHC measured total moisture content of the meat. In addition, the tightly bound water in the carrageenan glaze, although released by pressure in the determination of WHC, may not have been readily expressed from the meat during initial chewing by panelists. As well, the bouillon-like flavor and spices in the gravy may have increased saliva production in the mouth, giving judges an impression of greater moistness of samples. Panelists' perception of the juiciness of GR FSH samples may also have been influenced by the slippery surface of the meat and by the fat content of any gravy adhering to the meat. These differences in juiciness and WHC may have been accented by the general dryness of all FSH samples, as indicated by the relatively low WHC values and by the low juiciness scores (Table 9).

In general, scores for the appearance and palatability of FSH "ready-prepared" roast beef packaged in GR and GLZ indicate that both products were desirable. In related experiments, other researchers (Bramblett et al., 1965; Baldwin and Korschgen, 1968; Korschgen et al., 1970; and Cremer and Chipley, 1980) have also obtained acceptable fresh "ready-prepared" roast beef.

Fresh and Frozen-Stored Samples

Means and F-values for data comparing FSH and FZN-S "ready-prepared" roast beef packaged in GR and GLZ are summarized in Table 10. For the overall appearance, color,

Table 10. Means and F-values for Comparisons C13 and C14[1] for subjective and objective data on "ready-prepared" roast beef packaged in gravy and carrageenan glaze - fresh and frozen-stored[2].

	C13			C14		
	GR			GLZ		
Measurements	FSH	FZN-S	F-value	FSH	FZN-S	F-value
Subjective						
Slice evaluation[3]						
Overall appearance	3.3	3.3	0.32	3.4	3.0	20.23**
Color	3.4	3.4	0.21	3.5	3.2	8.74**
Grain	3.6	3.6	0.08	3.5	2.5	107.18**
Degree of doneness	3.1	3.0	3.96	3.3	3.0	5.25*
Uniformity of doneness	3.7	3.7	0.02	4.0	3.9	0.94
Trained taste panel[4]						
Desirability of - aroma	5.3	5.0	12.42**	5.3	5.0	22.13**
- flavor	5.1	4.8	11.93**	5.1	5.0	5.32*
Intensity of beefy - aroma	5.1	4.6	44.54**	5.0	4.4	80.01**
- flavor	5.2	4.8	15.38**	4.9	4.5	20.94**
Intensity of warmed-over - aroma	6.6	6.5	0.03	6.3	6.5	7.50**
- flavor	6.6	6.7	0.86	6.3	6.5	12.03**
Tenderness	4.8	4.6	8.73**	4.8	4.7	3.12
Juiciness	3.8	3.7	0.05	3.2	3.3	0.56
Overall acceptability	5.0	4.6	16.70**	4.8	4.5	5.87*
Objective						
TBA value (mg malonaldehyde/kg)[5]	1.4	1.5	1.23	1.7	1.4	3.17
Shear force (kg/g)[5]	0.25	0.27	2.92	0.27	0.26	1.00
Water holding capacity[6]	0.51	0.38	47.65**	0.55	0.44	31.02**

[1] See Figure 2, page 32, for descriptions of comparisons.
[2] See Figure 1, page 30, for descriptions of treatment abbreviations.
[3] Maximum score, 5. Values are the means of 96 judgements, one per cooking method per replication per each of four panelists.
[4] Maximum score, 7. Values are the means of 192 judgements, one per cooking method per replication per each of eight panelists.
[5] Values are the means of 48 determinations, two per cooking method per replication.
[6] Values are the means of 72 determinations, three per cooking method per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

grain, degree of doneness and uniformity of doneness of GR samples, there were no significant differences due to freezing and storage. Bramblett et al. (1965) also noted no alteration in the appearance of cooked sliced beef in gravy after three months frozen storage. Data (Table 10) for samples covered with GLZ show that freezing and storage had a significant detrimental effect on the overall appearance, color, grain and degree of doneness of beef slices. However, both FSH and FZN-S samples in GLZ were similar in uniformity of doneness. For both FSH and FZN-S samples, judges occasionally described GLZ beef slices as greyish in color. A sediment on the surface of beef slices, which was probably due to adhering gravy or glaze, was also observed.

For each type of package addition, the desirability of aroma and flavor of beef samples (Table 10) decreased significantly with freezing and storage, although differences in flavor scores between GLZ FSH and GLZ FZN-S samples are slight. Bramblett et al. (1965) reported a slight decrease in the flavor score for cooked sliced beef in gravy after three months frozen storage. Korschgen et al. (1970) noted no significant differences in the aroma and flavor of fresh and short frozen-stored roast beef slices in gravy. For cooked beef slices packaged without gravy, Baldwin and Korschgen (1968) and Korschgen et al. (1970) found that fresh samples were scored higher for aroma and flavor than comparable samples reheated after one and three

months frozen storage, respectively.

For each type of package addition, the intensity of beefy aroma and flavor was weakened ($P < 0.01$) by freezing and storage (Table 10). Judges often commented that the aroma and flavor of FSH (GR and GLZ) samples were "beefy" while comparable FZN-S samples were "weak" in odor and flavor.

For GR samples, no differences in WOA and WOF intensity attributable to freezing and storage were noted. However, for GLZ treatments, FSH samples were judged to be more ($P < 0.01$) warmed-over than comparable FZN-S treatments, although the difference in actual scores is not large. No reason for this finding is readily apparent. Perhaps the decrease in beefy intensity of meat samples due to freezing and storage reduced panelists' ability to detect WOA and WOF in GLZ FZN-S samples. In GR samples, the bouillon-like aroma and flavor may have masked a weakened beefy intensity and WOA/WOF intensity.

Although GR FSH samples were more tender ($P < 0.01$) than comparable GR FZN-S samples (Table 10), this small difference may not have practical meaning. Freezing and storage had no significant effect on the tenderness of GLZ samples. Bramblett et al. (1965) and Korschgen et al. (1970) noted no significant changes in the tenderness of cooked sliced beef in gravy due to frozen storage (three months).

In the present experiment, no significant differences in the juiciness of GR and GLZ samples attributable to freezing and storage were determined (Table 10). Bramblett

et al. (1965) noted only a slight decrease in the juiciness of cooked sliced beef in gravy with freezing and storage (three months). In contrast, for cooked sliced beef packaged with and without gravy, Korschgen et al. (1970) reported significantly higher juiciness scores for fresh than for comparable frozen-stored (three months) samples.

For both GR and GLZ treatments, the overall acceptability of FSH samples was scored significantly higher than that of comparable FZN-S samples. Korschgen et al. (1970) obtained similar results for plain samples of cooked sliced beef; however samples packaged in gravy showed no decrease in overall acceptability after three months frozen storage.

The FZN-S treatment had no significant effect on the TBA value of either GR or GLZ beef slices (Table 10). These data support subjective evaluations for the WOA and WOF of comparable GR samples but disagree with sensory data for the same GLZ samples. As described earlier, TBA values were generally low compared to those of the anchor for WOA/WOF and therefore substantiate taste panelists' perception of little or no WOA and WOF in any sample.

Shear force values for FSH and FZN-S samples with GR and GLZ did not differ significantly. These data substantiate sensory evaluations for the tenderness of GLZ treatments and tend to support subjective data for the tenderness of GR samples. The WHC value for both GR and GLZ treatments decreased significantly with freezing and storage.

These data do not substantiate sensory scores for juiciness. Buck et al. (1979) also noted that press fluid values did not substantiate juiciness scores for roast beef.

Frozen-Stored Samples

Data for the effects of type of package addition on the palatability characteristics of FZN-S "ready-prepared" roast beef are presented in Table 11. GR FZN-S beef slices received higher ($P < 0.01$) scores for overall appearance and grain than did comparable GLZ samples. No significant differences attributable to package addition were noted for color, degree of doneness and uniformity of doneness of beef slices. Judges occasionally noted a greenish iridescence on the surface of both GR and GLZ FZN-S meat slices.

Type of package addition had no significant effect on the desirability of aroma and flavor of FZN-S "ready-prepared" roast beef. Korschgen et al. (1970) noted no significant difference in aroma scores for cooked beef slices frozen three months with and without gravy. However, they (Korschgen et al., 1970) reported higher flavor scores for samples with gravy than for comparable samples without gravy.

In the present study, GR FZN-S beef samples had a more intense ($P < 0.01$) beefy aroma and flavor than comparable GLZ FZN-S beef (Table 11). As described earlier, the aroma and flavor of GR FZN-S beef tended to be "bouillon-like", while GLZ FZN-S samples were described as "beefy" and less artificial in odor and flavor than comparable GR slices.

Table 11. Means and F-values for subjective and objective data on "ready-prepared" roast beef packaged in gravy and carrageenan glaze - frozen-stored.

Measurements		Package Addition[1] GR	GLZ	F-value
Subjective				
Slice evaluation[2]				
Overall appearance		3.3	3.0	8.99**
Color		3.4	3.2	3.88
Grain		3.6	2.5	87.05**
Degree of doneness		3.0	3.0	0.00
Uniformity of doneness		3.7	3.9	1.80
Trained taste panel[3]				
Desirability of	- aroma	5.0	5.0	0.28
	- flavor	4.8	5.0	3.65
Intensity of beefy	- aroma	4.6	4.4	16.57**
	- flavor	4.8	4.5	11.70**
Intensity of warmed-over	- aroma	6.5	6.5	0.89
	- flavor	6.7	6.5	5.21*
Tenderness		4.6	4.7	1.95
Juiciness		3.7	3.3	8.78**
Overall acceptability		4.6	4.5	0.22
Objective				
TBA value (mg malonaldehyde/kg)[4]		1.5	1.4	0.51
Shear force (kg/g)[4]		0.27	0.26	1.48
Water holding capacity[5]		0.38	0.44	8.41**

[1] See Figure 1, page 30, for descriptions of treatment abbreviations.

[2] Maximum score, 5. Values are the means of 96 judgements, one per cooking method per replication by each of four panelists.

[3] Maximum score, 7. Values are the means of 192 judgements, one per cooking method per replication by each of eight panelists.

[4] Values are the means of 48 determinations, two per cooking per replication.

[5] Values are the means of 72 determinations, three per cooking method per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

No significant difference in WOA intensity attributable to type of package addition was noted for FZN-S "ready-prepared" roast beef. GLZ FZN-S samples were judged as having more ($P < 0.05$) WOF than comparable GR treatments. However, the generally high scores indicate the presence of very little WOA and WOF in either GR or GLZ FZN-S beef. The WOF in GR FZN-S samples may have been masked by the bouillon-like flavor of the gravy.

There was no significant difference in tenderness between GR FZN-S and GLZ FZN-S treatments (Table 11). Korschgen et al. (1970) found cooked beef slices frozen (three months) with gravy to be more tender than comparable samples frozen without gravy. In the present study, GR FZN-S samples were juicier ($P < 0.01$) than comparable GLZ FZN-S treatments. Korschgen et al. (1970) found no significant difference in juiciness scores between plain and gravied cooked sliced beef stored frozen for three months. Panelists judged the overall acceptability of FZN-S "ready-prepared" roast beef packaged with either GR or GLZ to be similar (Table 11). Korschgen et al. (1970) reported a higher general acceptability score for cooked sliced beef frozen (three months) in gravy than for comparable samples packaged without gravy.

TBA values were similar for both FZN-S package addition treatments (Table 11). These data support sensory scores for WOA intensity and, since the difference in flavor scores is small, also tend to substantiate scores for WOF intensity.

The difference in degree of WOF detected by judges for GR and GLZ samples may have been more related to other types of flavor difference rather than to an actual difference in degree of lipid oxidation between the type of package addition. TBA values in general, compared to those obtained for the WOA/WOF anchor, indicate the presence of very little lipid oxidation in the beef samples.

Shear force values for GR FZN-S and GLZ FZN-S treatments did not differ. These data agree with sensory scores for tenderness. The WHC value for GLZ FZN-S "ready-prepared" roast beef was significantly higher than that obtained for comparable GR FZN-S samples. Possible explanations for lack of agreement between sensory and objective data were presented earlier.

Although FZN-S "ready-prepared" roast beef packaged in GLZ was judged as having a coarse grain, trained panelists generally found the palatability of GR FZN-S and GLZ FZN-S beef to be comparable and desirable, particularly with regard to degree of WOA and WOF. Korschgen et al. (1970) reported that roast beef slices frozen three months in gravy in foil trays were desirable in eating quality while comparable samples frozen without gravy tended to be undesirable. The results of Korschgen et al. (1970) and those of the present study suggest that the carrageenan glaze protects the eating quality of frozen-stored beef slices as well as gravy, while packaging roast beef slices untreated is less effective.

Packages for Bulk Service

Temperatures and Reheating Times

Samples representing the CONV-1 and CONV-2, WB and AS cooking method treatments (see Figure 1, page 30) were frozen in gravy in bulk aluminum foil trays (BLK GR) and stored for an average of two weeks before being reheated for evaluation. Just prior to LCO_2 freezing, the average center temperature of BLK GR roast beef was 14.1° (range, 8.1° to 18.6°). Immediately after LCO_2 freezing, the center temperature of all packages of BLK GR roast beef was below 0°; the average temperature was -1.3° (range, -0.6° to -2.5°). These values are the means of 24 measurements, one per cooking method per replication.

BLK GR FZN-s roast beef samples required an average reheating time of 26.8 ± 4.7 min to attain a final internal temperature of 80°. This value is the mean of 24 measurements, one per cooking method treatment per replication.

Sensory Evaluation by Consumer Panel

Consumer acceptance of the "ready-prepared" roast beef was determined by serving BLK FZN-S roast beef samples in gravy to a taste panel consisting of 127 hospital staff members. The evaluation was conducted under cafeteria-style conditions.

Demographic data (sex and age), obtained from consumer panelists on a voluntary basis, are presented in Table 12. Of the 62 individuals who evaluated CONV-1 and WB samples

Table 12. Sex and age of participants in consumer evaluation of "ready-prepared" roast beef.

	Group 1[1]		Group 2[2]	
	Number	Percentage	Number	Percentage
Total	62	100	65	100
Sex				
Male	20	32	7	11
Female	39	63	50	77
Not given	3	5	8	12
Age				
18 years	1	2	1	2
19 - 25 years	15	24	19	29
26 - 35 years	24	39	19	29
36 - 50 years	15	24	10	15
51 - 65 years	4	6	10	15
Not given	3	5	6	9

[1]Consumers evaluating CONV-1 and WB samples.

[2]Consumers evaluating CONV-2 and AS samples.

(Group 1 consumers), 32% indicated they were male and 63% indicated they were female. The majority (39%) of these 62 participants were known to be in the 26 to 35 year age group. Approximately 5% of Group 1 consumers did not indicate their sex and 5% did not give their age. Of the 65 consumer panelists who evaluated CONV-2 and AS samples (Group 2 consumers), 11% indicated they were male and 77% indicated they were female; 58% of Group 2 consumers were known to be equally distributed between the 19 to 25 and 26 to 35 year age groups. Twelve percent of Group 2 participants did not indicate their sex and 9% did not give their age. The large proportion of female participants in the consumer evaluation was expected, since the group was drawn from hospital staff.

Data from the consumer evaluation of BLK GR FZN-S "ready-prepared" roast beef cooked by the CONV-1 and WB methods are presented in Table 13. Consumer panelists detected no significant differences attributable to cooking method for any of the quality characteristics evaluated. Samples were generally rated as acceptable (3 to 4 on a five-point scale).

The differences in flavor desirability and tenderness between CONV and WB samples noted by trained panelists for IND GR treatments (see Appendix, Table 30, Comparison C4, page 164) were not detected by consumer panelists in their evaluation of BLK GR treatments (Table 13). The warm holding of the BLK roast beef slices in gravy for up to 30 min may have eliminated the tenderness in BLK WB samples that

Table 13. Means and F-values for Comparison C1[1] for consumer data on frozen-stored, bulk-packaged, "ready-prepared" roast beef in gravy cooked by the conventional and water bath methods.

Characteristic[3]	Cooking Method[2] CONV-1	WB	F-value
Appearance	3.6	3.6	0.49
Flavor	3.5	3.3	1.90
Tenderness	2.8	3.1	1.76
Juiciness	3.1	3.1	0.02
Temperature	3.4	3.4	1.93
Overall acceptability	3.3	3.3	0.03

[1]See Figure 2, page 32, for description of comparison.
[2]See Figure 1, page 30, for descriptions of treatment abbreviations.
[3]Maximum score, 5. Values are the means of 62 judgements.

Table 14. Means and F-values for Comparison C2[1] for consumer data on frozen-stored, bulk-packaged, "ready-prepared" roast beef in gravy cooked by the conventional and Alto-Shaam methods.

Characteristic[3]	Cooking Method[2] CONV-2	AS	F-value
Appearance	3.8	3.6	3.69
Flavor	3.4	3.1	2.31
Tenderness	2.8	2.4	7.76*
Juiciness	3.1	2.4	21.65**
Temperature	3.4	3.5	2.32
Overall acceptability	3.4	3.1	4.36

[1]See Figure 2, page 32, for description of comparison.
[2]See Figure 1, page 30, for descriptions of treatment abbreviations.
[3]Maximum score, 5. Values are the means of 65 judgements.

Table 15. Means and F-values for Comparison C3[1] for consumer data on frozen-stored, bulk-packaged, "ready-prepared" roast beef in gravy cooked by the water bath and Alto-Shaam methods.

Characteristic[3]	Cooking Method[2] WB[4]	AS[5]	F-value
Appearance	3.6	3.6	1.82
Flavor	3.3	3.1	0.04
Tenderness	3.1	2.4	6.20
Juiciness	3.1	2.4	6.82*
Temperature	3.4	3.5	2.65
Overall acceptability	3.3	3.1	0.90

[1]See Figure 2, page 32, for description of comparison.
[2]See Figure 1, page 30, for descriptions of treatment abbreviations.
[3]Maximum score, 5.
[4]Values are the means of 62 judgements
[5]Values are the means of 65 judgements.
* Significant at $P < 0.05$
** Significant at $P < 0.01$

was noted by the trained judges in IND WB GR beef. In addition, the gravy accompanying consumer roast beef samples may have masked the treatment effects noted by the trained taste panel who evaluated samples with the gravy removed.

Summarized in Table 14 are means and F-values for data from the consumer evaluation of BLK GR FZN-S "ready-prepared" roast beef cooked by the CONV-2 and AS methods. For the appearance, flavor and temperature of BLK GR FZN-S beef slices, consumer panelists detected no significant differences attributable to the CONV and AS cooking methods. However, CONV BLK GR samples were rated significantly higher for tenderness and juiciness than comparable AS beef slices. Although the difference is not significant, the overall acceptability score for CONV BLK GR beef samples also tends to be higher than that for comparable AS beef.

Trained panelists judged the tenderness and juiciness of CONV-2 and AS samples from IND GR treatments to be similar (see Appendix, Table 30, Comparison C5, page 164). Perhaps the warm holding of BLK GR beef slices for cafeteria service decreased the tenderness and juiciness of the AS beef samples which the consumers evaluated (Table 14). Consumer overall acceptability scores for CONV and AS beef slices (BLK GR) tend to agree with trained taste panel scores for the overall acceptability of IND GR treatments prepared by these cooking methods.

Means and F-values for the consumer evaluation of BLK GR FZN-S "ready-prepared" roast beef cooked by the WB and AS

methods are shown in Table 15. There were no significant differences in the appearance, flavor, temperature and overall acceptability of BLK GR FZN-S samples due to the WB and AS cooking methods. The tenderness score for WB BLK GR samples was higher ($P < 0.055$), although not significantly so, than that for comparable AS samples. WB BLK GR samples were also juicier ($P < 0.05$) than AS BLK GR beef slices.

Consumer ratings for the tenderness and juiciness of BLK GR FZN-S "ready-prepared" roast beef (Table 15) tend to agree with trained taste panel evaluations of comparable IND GR treatments for these quality attributes (see Appendix, Table 30, Comparison C6, page 164). However, trained judges scored the overall acceptability of WB IND GR FZN-S beef slices higher than that of comparable AS samples.

Consumers rated AS BLK FZN-S beef samples (Tables 14 and 15) between "unacceptable" and "neither acceptable nor unacceptable" (2 to 3 on a five-point scale) for tenderness and juiciness. Thus, the AS cooking method may not be appropriate for the preparation of BLK "ready-prepared" roast beef to be held warm in gravy for cafeteria service.

Generally, the hospital staff consumer panelists judged the quality of BLK GR FZN-S "ready-prepared" roast beef cooked by CONV and WB methods between "neither acceptable nor unacceptable" and "acceptable" (3 to 4 on a five-point scale). Results from previous consumer surveys of hospital food and foodservice (Maller et al., 1980; and Roles, 1980) suggest that patient ratings of roast beef, and of hospital

food quality in general, are typically higher than staff ratings. Reasons for the more critical attitude of hospital staff may be that staff are more familiar with the food and that they pay directly for their meals. Thus, patient acceptance of "ready-prepared" BLK GR roast beef would probably be greater than that obtained from these staff ratings (Tables 13, 14 and 15).

These data (Tables 13, 14 and 15) obtained for frozen-stored, "ready-prepared" roast beef compare favorably to those found for traditionally-prepared roast beef in previous hospital surveys of food quality (Maller et al., 1980; and Roles, 1980). Other researchers (Glew et al., 1969/70; and Millross et al., 1973) using consumer questionnaires, have found that the general quality of food prepared in a cook-freeze system can be as good as that of food prepared in a traditional foodservice operation. However, most other workers (Glew et al., 1969/70; Millross et al., 1973; and Maller et al., 1980) have not included evaluations of all of the important quality characteristics of roast beef.

SUMMARY AND CONCLUSIONS

Beef biceps femoris roasts were cooked by the conventional institution (CONV), hot-water bath (WB) and Alto-Shaam (AS) methods, chilled and sliced thinly. The cooked beef slices were then packaged with either gravy (GR) or carrageenan glaze (GLZ) in individual-serving Traytite® containers (IND) and with GR in bulk aluminum foil trays (BLK). IND treatments were reheated either immediately after packaging as fresh controls (FSH) or after freezing and frozen storage (FZN-S) for three weeks. BLK GR beef slices were reheated after an average of two weeks of frozen storage. Quality characteristics of IND "ready-prepared" roast beef as affected by cooking method, type of package addition and frozen storage were evaluated by trained panels and by instrumental and chemical techniques. A consumer panel evaluated the quality of BLK GR roast beef samples under cafeteria conditions.

Data for the effects of cooking method on whole roasts show that the CONV cooking time was the fastest, followed by the AS method, and that the WB method required more than twice as long to cook roasts as the CONV method. The average percentage total cooking losses for roasts show no significant differences due to cooking method. For CONV roasts, the largest portion of the total cooking loss was evaporative. WB roasts had no appreciable volatile loss; whereas roasts cooked by the AS method had generally similar volatile and drip losses. Percentage drip loss during

chilling was greater for CONV roasts than for comparable AS and WB roasts which were generally similar. Percentage total cooking/chilling losses of CONV roasts were significantly higher than those of roasts from the WB and AS treatments. CONV roasts shrank more ($P < 0.01$) in length after cooking and chilling than comparable WB roasts. CONV roasts also tended to shrink more in length than AS roasts.

For IND FSH "ready-prepared" roast beef, no significant differences attributable to cooking method (CONV, WB and AS) were observed in slice evaluation scores for overall appearance, color, degree of doneness and uniformity of doneness. However, WB FSH beef slices had a finer, more attractive grain ($P < 0.01$) than comparable CONV samples. No differences in scores for grain between either CONV FSH and AS FSH or between WB FSH and AS FSH beef slices were found. Trained panelists detected no effects of cooking method on the desirability of aroma and flavor, intensity of beefy flavor, intensity of warmed-over aroma (WOA) and warmed-over flavor (WOF), juiciness and overall acceptability of FSH "ready-prepared" roast beef. However, AS FSH beef slices had a more ($P < 0.01$) intense beefy aroma than comparable CONV samples. No differences in intensity of beefy aroma between either CONV FSH and WB FSH or between WB and AS treatments were observed. WB FSH samples were more ($P < 0.05$) tender than comparable CONV beef slices and tended to be more tender than AS samples. CONV FSH and AS FSH samples were similar in tenderness. There were no

differences in the thiobarbituric acid (TBA) and water holding capacity (WHC) values of FSH samples due to cooking method. For FSH beef slices, shear force values tended to be lower for WB and CONV beef than for AS samples.

Findings for FSH and FZN-S "ready-prepared" roast beef show no significant effects due to freezing and storage for the overall appearance of CONV and AS samples. The appearance of WB FSH beef was scored higher ($P < 0.01$) than that of comparable WB FZN-S samples. There were no differences due to freezing and storage for the color and uniformity of doneness of beef slices representing each cooking method. CONV FSH and CONV FZN-S beef slices were rated as similar in well-doneness, however WB FSH and AS FSH beef slices were judged to be less well-done than comparable FZN-S samples. FSH samples cooked by each method had a finer ($P < 0.01$) grain than FZN-S beef slices. FSH samples representing each cooking technique were rated higher ($P < 0.01$) for aroma desirability than comparable FZN-S samples. CONV FSH and CONV FZN-S beef slices received similar scores for flavor desirability. However, WB FSH and AS FSH samples were rated significantly higher in flavor desirability than comparable FZN-S samples. For samples cooked by each method, intensity of beefy aroma and flavor decreased significantly with freezing and storage. Generally, freezing and storage had no effect on WOA/WOF scores for samples representing each cooking method, although judges more often described FSH samples as having a

"fresh" aroma and flavor. CONV FSH and CONV FZN-S samples were similar in tenderness. WB FSH and AS FSH beef slices were rated significantly higher in tenderness than comparable FZN-S samples. Freezing and storage had no effect on the juiciness of beef slices from each cooking procedure. Although FSH samples representing each cooking method were scored significantly higher than FZN-S samples for overall acceptability, scores for this attribute indicate that all products were good. Shear force and TBA values for beef slices cooked by each method show no differences attributable to the FZN-S treatment. For each cooking procedure, WHC values decreased ($P < 0.01$) with freezing and storage.

For FZN-S "ready-prepared" roast beef, there were no significant differences in slice evaluation scores due to cooking method. Desirability of aroma and flavor, intensity of beefy aroma and flavor, and intensity of WOA of CONV FZN-S and WB FZN-S samples did not differ. Though CONV FZN-S beef slices had more ($P < 0.01$) WOF than comparable WB slices, the practical difference is slight. The juiciness, tenderness and overall acceptability of WB FZN-S samples were scored significantly higher than comparable CONV FZN-S beef. For FZN-S "ready-prepared" roast beef there were generally no differences in the quality attributes of beef slices prepared by the CONV and AS procedures. Although the desirability of aroma and flavor, intensity of beefy aroma and overall acceptability of CONV FZN-S beef were scored significantly

higher than those of comparable AS FZN-S samples, the differences are small. CONV FZN-S samples tended to be more tender than AS FZN-S samples. Judges rated the desirability of aroma, intensity of beefy aroma and flavor, intensity of WOF, tenderness, juiciness and overall acceptability of WB FZN-S samples significantly higher than those of AS FZN-S slices, though differences in aroma and flavor scores are negligible. In addition, no differences in flavor desirability and WOA intensity between WB FZN-S and AS FZN-S treatments were noted.

For FZN-S samples, no differences due to the three cooking procedures were obtained for TBA values, which are low and substantiate the high sensory scores for WOA/WOF. The shear force value for WB FZN-S beef was significantly lower than that for CONV FZN-S samples and it tended to be lower than that for AS FZN-S slices. No differences in WHC values of FZN-S beef from the three cooking procedures were found.

For FSH "ready-prepared" roast beef treated with GR and GLZ, no differences due to type of package addition were noted for overall appearance, color, grain and degree of doneness. GLZ FSH samples were scored higher ($P < 0.05$) for uniformity of doneness than GR FSH beef slices. Panelists detected no differences between GR FSH and GLZ FSH treatments for desirability of aroma and flavor. GR FSH samples were judged to have a slightly but significantly more intense beefy aroma and flavor as well as less

($P < 0.01$) WOA/WOF than GLZ FSH samples. The aroma and flavor of GR FSH treatments were characterized as "bouillon-like" while GLZ FSH samples were described as "beefy", "fresh" and "weak". No differences in tenderness and overall acceptability of FSH samples due to type of package addition were noted. GR FSH beef slices were judged to be juicier ($P < 0.01$) than GLZ FSH samples. There were no significant differences due to package addition for the TBA and shear force values of FSH samples. WHC values were higher ($P < 0.05$) for GLZ FSH than for comparable GR beef slices.

Scores for appearance characteristics of "ready-prepared" roast beef were similar for FSH and FZN-S samples packaged in GR. However, freezing and storage had a significant detrimental effect on the overall appearance, color, degree of doneness and, in particular, the grain of beef slices packaged in GLZ. For each type of package addition, the desirability of aroma and flavor of beef samples decreased significantly with freezing and storage, although the flavor difference for GLZ samples is slight. For both GR and GLZ, the intensity of beefy aroma and flavor was weakened ($P < 0.01$) by freezing and storage. As well, judges often described the aroma and flavor of FSH samples as "beefy" while FZN-S beef slices were "weak". For GR samples, no difference in WOA/WOF intensity due to freezing and storage was noted. GLZ FSH samples were perceived as having slightly but significantly more WOA and WOF than GLZ

FZN-S samples. GR FSH samples were more ($P < 0.01$) tender than GR FZN-S samples; freezing and storage had no effect on the tenderness of GLZ samples. There were no significant differences in the juiciness of GR and GLZ samples due to freezing and storage. For both GR and GLZ beef slices, the overall acceptability of FSH samples was scored significantly higher than that of comparable FZN-S beef. Freezing and storage had no significant effect on the TBA and shear force values obtained for either GR or GLZ beef slices. The WHC value for both GR and GLZ treatments decreased ($P < 0.01$) with freezing and storage.

Data for FZN-S "ready-prepared" roast beef packaged in GR and GLZ show that GR FZN-S samples received higher ($P \leq 0.01$) scores for overall appearance and grain than GLZ FZN-S samples. No significant differences due to type of package addition were found for color, degree of doneness, uniformity of doneness and for the desirability of aroma and flavor of FZN-S beef. GR FZN-S beef samples had a more intense ($P < 0.01$) beefy aroma and flavor than GLZ FZN-S slices. Again, GR FZN-S beef slices tended to be "bouillon-like"; GLZ FZN-S samples were described as "beefy" and less artificial in odor and flavor. Sensory scores for FZN-S beef indicated the presence of very little WOA/WOF. GR and GLZ samples received similar scores for WOA intensity; GLZ FZN-S samples had slightly but significantly more WOF than GR FZN-S beef slices. The tenderness of GR FZN-S and GLZ FZN-S beef was similar, however GR FZN-S samples were

juicier ($P < 0.01$) than comparable GLZ FZN-S slices. Overall acceptability scores, TBA numbers and shear force values for FZN-S "ready-prepared" roast beef show no significant differences due to type of package addition. The WHC value for GLZ FZN-S samples was higher ($P < 0.01$) than that obtained for GR FZN-S samples.

Frozen-stored, "ready-prepared" roast beef cooked by the CONV, WB and AS methods was evaluated by 127 hospital staff consumer panelists under simulated cafeteria-style conditions. Data for BLK GR FZN-S treatments show that consumer panelists detected no significant differences among the three cooking methods for appearance, flavor, temperature and overall acceptability. Although both CONV BLK GR FZN-S and WB BLK GR FZN-S samples received similar tenderness scores, CONV BLK GR FZN-S slices were rated higher ($P < 0.05$) than comparable AS samples for tenderness. WB BLK GR FZN-S samples also tended to be rated higher ($P < 0.055$) than comparable AS beef slices for tenderness. Consumers judged CONV BLK GR FZN-S and WB BLK GR FZN-S beef to be similar in juiciness, however both CONV and WB treatments received significantly higher juiciness scores than comparable AS samples. In general, CONV BLK GR FZN-S and comparable WB "ready-prepared" roast beef slices were judged by consumers to be "neither acceptable nor unacceptable" to "acceptable" in quality.

Results of the experiment suggest that, because of their lower cooking/chilling losses and reduced shrinkage

(in roast length), the WB and AS methods of preparing roast beef offer more economical alternatives than the traditional institutional cooking method. Each of the three cooking procedures resulted in acceptable frozen-stored, "ready-prepared" roast beef when packaged in IND Traytite® containers. However, the data indicate that WB IND FZN-S samples were more tender, juicier and more acceptable in overall eating quality than comparable CONV and AS samples. CONV IND FZN-S samples tended to be more tender and were judged to be better in overall acceptability than comparable AS samples. Consumer evaluations of the tenderness of bulk-packaged, frozen-stored, "ready-prepared" roast beef in gravy tend to support data obtained from trained panelists for the tenderness of similar beef samples packaged in Traytite® containers. Because the AS samples received low consumer panel scores ("unacceptable" to "neither acceptable nor uancceptable") for tenderness and juiciness, the AS cooking method may not be appropriate for the preparation of frozen-stored, "ready-prepared" roast beef in gravy for cafeteria service.

WOA/WOF scores for "ready-prepared" roast beef were generally not affected by cooking method. Trained panelists detected little or no oxidative rancidity in frozen-stored beef treated with either package addition, although beef slices covered with GLZ had a coarse, less attractive grain than comparable samples packaged with GR. Thus, carrageenan glaze appears to be as effective as gravy in protecting

cooked beef slices from developing WOA/WOF during short frozen storage. As well, glazed beef slices had a more natural beefy (though weaker) aroma and flavor than slices packaged with gravy, which had a "bouillon-like" odor and flavor. Therefore, carrageenan glaze may offer an alternative to gravy as a package addition for frozen-stored, "ready-prepared" roast beef. However, further investigations of the effectiveness of differing concentrations of carrageenan and of other gums in solutions as glazes in improving the appearance of frozen-stored, cooked beef slices are essential. Results from such studies would be particularly valuable for individuals who do not care for gravy or are on diets which do not permit gravy.

For frozen-stored, "ready-prepared" roast beef in Traytite® packaging, the WB cooking method and GR as a package addition resulted in juicier beef slices than did the CONV and AS cooking methods and GLZ treatment, respectively. However, all beef samples were rated "slightly dry" to "neither juicy nor dry". In addition, slice evaluation scores and WHC values confirmed that all beef slices were dry. The use of thin slices combined with reheating to 80° probably accounts for this dryness in the meat. Further research is required to determine whether increasing the slice thickness and lowering the internal temperature to which beef slices are reheated can improve the juiciness of frozen-stored, "ready-prepared" roast beef. Microbiological testing would be pertinent in this kind of a study.

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APPENDIX

Table 16. Analyses of variance for chemical composition data on raw biceps femoris roasts.

Source of Variation	Degrees of Freedom	pH MS[1]	pH SE[2]	Total Moisture (%) MS	Total Moisture (%) SE	Ether Extract (%) MS	Ether Extract (%) SE
Replication (A)	5	0.01	0.02	5.08	0.62	5.62	0.67
Cooking Method (B)[3]	3	0.00	0.02	1.54	0.51	0.32	0.54
AB[4]	15	0.00		3.08		3.55	
Error	24	0.00		0.00		0.00	
Total	47						
Comparisons[5]							
C1 Treatment	1	0.00		0.83		0.02	
Error	5	0.00		0.57		0.24	
C2 Treatment	1	0.00		0.00		0.23	
Error	5	0.00		0.49		0.20	
C3 Treatment	1	0.00		0.41		0.06	
Error	5	0.00		0.72		0.30	

[1]Mean square

[2]Standard error

[3]SE estimated using AB interaction.

[4]Valid error term for testing significance of replication variation.

[5]See Figure 2, page 32, for descriptions of comparisons.

Table 17. Analyses of variance for objective data on whole roasts.

Source of Variation	Degrees of Freedom	Weight (kg) MS[1]	Weight (kg) SE[2]	Thaw Loss (%) MS	Thaw Loss (%) SE	Cooking Time (min) MS	Cooking Time (min) SE	Cooking Time (min/kg) MS	Cooking Time (min/kg) SE	Final Internal Temp (°C) MS	Final Internal Temp (°C) SE
Replication (A)	5	0.44	0.25	1.75	0.66	719.38	6.77	18.68	2.91	1.53	0.39
Cooking Method (B)[3]	3	0.09	0.20	0.13	0.54	50315.92	5.54	3331.84	2.37	0.81	0.31
AB[4]	15	0.24		1.74		183.58		33.82		0.59	
Total	23										
Comparisons[5]											
C1 Treatment	1	0.13		0.06		119935.30		756.13		0.08	
Error	5	0.04		1.15		103.55		21.27		1.07	
C2 Treatment	1	0.00		0.10		5701.93		399.63		1.69	
Error	5	0.03		0.86		79.04		7.19		0.44	
C3 Treatment	1	0.07		0.00		36667.85		2242.47		0.51	
Error	5	0.01		0.76		103.04		14.39		0.48	

Source of Variation	Degrees of Freedom	Cooking Losses (%) Total MS	Total SE	Volatile MS	Volatile SE	Drip MS	Drip SE	Chilling Drip (%) MS	Chilling Drip (%) SE	Total Cooking/ Chilling Loss (%) MS	Total Cooking/ Chilling Loss (%) SE
Replication (A)	5	5.31	0.68	1.86	0.43	2.05	0.57	0.14	0.69	4.88	0.69
Cooking Method (B)[3]	3	4.27	0.56	337.09	0.35	272.74	0.47	1.17	0.11	8.65	0.56
AB[4]	15	1.87		0.75		1.31		0.08		1.89	
Total	23										
Comparisons[5]											
C1 Treatment	1	4.76		700.13		589.54		2.81		14.83	
Error	5	1.82		1.10		0.99		0.12		1.73	
C2 Treatment	1	1.69		194.73		160.31		0.69		4.54	
Error	5	0.48		0.80		1.14		0.05		0.29	
C3 Treatment	1	0.39		78.19		67.50		0.36		1.48	
Error	5	0.81		0.53		1.24		0.05		0.88	

Continued.

Table 17. Continued.

		Dimensional Change (%)					
	Degrees of	Length		Width		Depth	
Source of Variation	Freedom	MS[1]	SE[2]	MS	SE	MS	SE
Replication (A)	5	56.07	1.83	29.94	4.05	53.88	2.79
Cooking Method (B)[3]	3	123.94	1.50	16.80	3.31	11.72	2.28
AB[4]	15	13.45		65.68		31.08	
Total	23						
Comparisons[5]							
C1 Treatment	1	220.85		1.11		0.56	
Error	5	6.06		48.77		33.67	
C2 Treatment	1	129.50		48.04		22.03	
Error	5	26.58		56.90		35.27	
C3 Treatment	1	6.06		17.27		7.79	
Error	5	19.90		92.77		27.97	

[1]Mean square

[2]Standard error

[3]SE estimated using AB interaction.

[4]Valid error term for testing significance of replication variation.

[5]See Figure 2, page 32, for descriptions of comparisons.

Table 18. Analyses of variance for slice evaluation panel data - fresh.

Source of Variation	Degrees of Freedom	Overall Appearance MS[1]	Overall Appearance SE[2]	Color MS	Color SE	Grain MS	Grain SE	Degree of Doneness MS	Degree of Doneness SE	Uniformity of Doneness MS	Uniformity of Doneness SE
Replication (A)	5	1.61	0.18	2.53	0.17	0.62	0.22	2.75	0.23	3.03	0.17
Cooking Method (B)[3]	3	0.75	0.15	0.02	0.14	3.56	0.18	3.67	0.19	1.70	0.14
AB[4]	15	1.03		0.93		1.50		1.64		0.96	
Package Addition (C)	1	0.33	0.11	0.81	0.10	0.47	0.12	2.19	0.15	3.80	0.09
AC	5	1.56		1.25		2.47		2.21		0.53	
BC	3	0.77		0.90		0.94		2.09		1.17	
ABC	15	1.04		0.78		0.87		1.97		0.89	
(AC,ABC)[5]	20	1.17		0.90		1.27		2.03		0.80	
Panelist (D)	3	1.70	0.10	1.43	0.11	2.91	0.09	14.49	0.09	15.60	0.10
AD	15	0.91		1.29		0.92		0.99		1.65	
BD	9	0.37		0.40		0.53		0.24		0.11	
ABD	45	0.57		0.57		0.36		0.43		0.54	
CD	3	0.88		1.58		0.20		0.54		0.06	
ACD	15	0.30		0.41		0.42		0.25		0.15	
BCD	9	0.10		0.18		0.22		0.21		0.29	
ABCD	45	0.29		0.35		0.19		0.31		0.24	
(AD,ABD,ACD,ABCD)[6]	120	0.47		0.56		0.37		0.43		0.52	
Total	191										
Comparisons[7]											
C1 Treatment	1	1.50		0.04		5.51		4.59		0.67	
Error	5	0.59		0.85		0.40		1.92		0.32	
C2 Treatment	1	0.01		0.00		0.94		0.21		4.17	
Error	5	1.41		1.03		2.87		1.04		1.57	
C3 Treatment	1	0.88		0.01		0.95		3.39		4.08	
Error	5	0.65		0.39		1.46		0.97		1.02	
C4 Treatment	1	0.01		0.42		0.42		0.02		0.19	
Error	5	0.32		0.37		0.76		2.22		0.60	
C5 Treatment	1	0.42		0.63		1.69		0.63		4.69	
Error	5	2.27		1.53		2.88		2.33		1.09	
C6 Treatment	1	0.17		1.04		0.21		0.21		1.50	
Error	5	1.16		0.72		1.13		0.94		0.62	
C7 Treatment	1	2.76		0.88		7.13		8.33		2.52	
Error	5	1.17		1.13		0.61		2.18		0.57	
C8 Treatment	1	0.63		0.52		0.01		2.08		0.52	
Error	5	0.78		0.83		1.06		0.73		0.87	
C9 Treatment	1	3.01		1.38		3.38		9.38		2.67	
Error	5	0.37		0.58		1.54		1.18		0.87	
C10 Treatment	1	0.13		0.38		0.59		0.75		6.77	
Error	5	1.66		1.14		1.78		4.72		0.69	
C11 Treatment	1	1.17		2.30		0.33		4.69		0.13	
Error	5	0.43		0.65		1.87		0.69		0.86	
C12 Treatment	1	0.19		0.33		0.75		0.19		0.33	
Error	5	1.58		1.05		0.86		1.04		0.93	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition variation.
[6] Valid error term for testing significance of panelist variation.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 19. Analyses of variance for slice evaluation panel data - frozen-stored.

Source of Variation	Degrees of Freedom	Overall Appearance MS[1]	SE[2]	Color MS	SE	Grain MS	SE	Degree of Doneness MS	SE	Uniformity of Doneness MS	SE
Replication (A)	5	1.49	0.19	1.70	0.21	0.39	0.10	2.15	0.24	0.21	0.17
Cooking Method (B)[3]	3	0.11	0.16	0.14	0.18	0.52	0.08	3.21	0.19	0.16	0.14
AB[4]	15	1.21		1.47		0.31		1.82		0.95	
Package Addition (C)	1	4.69	0.07	1.60	0.07	50.53	0.08	0.00	0.07	1.33	0.09
AC	5	0.45		0.40		0.61		0.56		0.81	
BC	3	0.63		0.55		0.19		0.60		0.80	
ABC	15	0.54		0.41		0.57		0.43		0.72	
(AC,ABC)[5]	20	0.52		0.41		0.58		0.46		0.74	
Panelist (D)	3	4.77	0.10	5.60	0.11	10.91	0.10	17.64	0.08	31.87	0.09
AD	15	0.49		0.77		1.03		0.48		0.53	
BD	9	0.75		1.02		0.15		0.38		0.11	
ABD	45	0.55		0.66		0.23		0.35		0.41	
CD	3	0.78		0.77		4.32		0.89		0.46	
ACD	15	1.02		0.77		0.96		0.21		0.44	
BCD	9	0.36		0.32		0.10		0.40		0.35	
ABCD	45	0.28		0.29		0.28		0.21		0.21	
(AD,ABD,ACD,ABCD)[6]	120	0.50		0.55		0.44		0.30		0.35	
Total	191										
Comparisons[7]											
C1 Treatment	1	0.32		0.13		0.17		0.07		0.44	
Error	5	0.34		1.18		0.32		0.63		0.79	
C2 Treatment	1	0.00		0.26		0.59		0.17		0.02	
Error	5	2.12		1.24		0.36		2.41		1.39	
C3 Treatment	1	0.13		0.38		0.06		0.22		0.13	
Error	5	1.64		2.28		0.33		1.18		1.88	
C4 Treatment	1	0.08		0.13		0.01		0.63		0.88	
Error	5	0.60		0.83		0.78		0.56		0.46	
C5 Treatment	1	0.42		1.02		0.42		0.19		1.17	
Error	5	0.86		0.53		0.12		1.10		0.62	
C6 Treatment	1	0.07		0.21		0.26		0.07		0.01	
Error	5	0.49		0.94		0.56		0.70		0.46	
C7 Treatment	1	1.17		0.75		0.42		0.19		0.00	
Error	5	0.40		0.69		1.05		0.48		0.99	
C8 Treatment	1	0.52		0.08		0.19		1.02		0.75	
Error	5	1.86		1.22		0.29		2.06		1.15	
C9 Treatment	1	0.07		0.17		0.02		0.17		0.38	
Error	5	1.63		1.74		0.35		0.64		1.76	
C10 Treatment	1	0.32		0.00		23.50		0.84		3.38	
Error	5	0.89		0.66		0.42		1.42		0.88	
C11 Treatment	1	3.00		1.88		17.52		0.42		0.05	
Error	5	0.35		0.28		1.52		0.12		0.35	
C12 Treatment	1	3.26		1.33		10.08		0.52		0.26	
Error	5	0.46		0.40		0.18		0.11		1.46	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition variation.
[6] Valid error term for testing significance of panelist variation.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 20. Analyses of variance for slice evaluation panel data - fresh and frozen-stored.

Source of Variation	Degrees of Freedom	Overall Appearance MS[1]	SE[2]	Color MS	SE	Grain MS	SE	Degree of Doneness MS	SE	Uniformity of Doneness MS	SE
Replication (A)	5	2.59	0.10	3.86	0.14	0.74	0.10	4.35	0.19	1.48	0.11
Cooking Method (B)[3]	3	0.25	0.08	0.06	0.11	2.09	0.08	5.42	0.16	0.86	0.09
AB[4]	15	0.67		1.27		0.60		2.32		0.82	
Package Addition (C)	1	1.26	0.07	0.07	0.06	30.38	0.07	2.50	0.09	4.82	0.07
BC	3	0.66		0.68		0.31		2.88		1.72	
Storage Treatment (D)	1	6.25	0.07	4.38	0.06	23.01	0.07	13.13	0.09	0.59	0.07
BD	3	0.62		0.10		1.99		1.43		0.99	
CD	1	3.76		2.34		20.63		0.07		0.32	
BCD	3	0.73		0.77		0.82		7.67		0.24	
(AC,ABC,AD,ABD,ACD,ABCD)[5]	60	1.00		0.75		0.94		1.43		0.93	
Panelist (E)	3	5.72	0.07	6.15	0.08	12.24	0.07	19.50	0.08	44.78	0.07
BE	9	0.75		1.00		0.23		0.68		0.11	
CE	3	1.48		1.78		3.06		0.96		0.28	
BCE	9	0.22		0.20		0.08		0.29		0.34	
DE	3	0.75		0.88		1.59		1.59		2.69	
BDE	9	0.37		0.41		0.45		0.42		0.11	
CDE	3	0.18		0.57		1.45		0.94		0.24	
BCDE	9	0.24		0.30		0.23		0.82		0.30	
(AE,AEB,AEC,AEBC,AED, AEBD,AECD,AEBCD)[6]	240	0.49		0.55		0.41		0.32		0.44	
Total	383										
Comparisons[7]											
C13 Treatment	1	0.16		0.16		0.03		5.67		0.02	
Error	60	1.00		0.75		0.94		1.43		0.93	
C14 Treatment	1	9.86		6.56		43.61		7.52		0.88	
Error	60	1.00		0.75		0.94		1.43		0.93	
C15 Treatment	1	1.33		2.08		3.26		1.33		0.16	
Error	60	1.00		0.75		0.94		1.43		0.93	
C16 Treatment	1	5.75		2.04		17.51		6.51		0.26	
Error	60	1.00		0.75		0.94		1.43		0.93	
C17 Treatment	1	0.94		0.51		8.17		9.38		2.19	
Error	60	1.00		0.75		0.94		1.43		0.93	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition and storage treatment variation.
[6] Valid error term for testing significance of panelist variation.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 21. Analyses of variance for trained taste panel data - fresh.

		Desirability				Beefy Intensity				Warmed-over	
	Degrees of	Aroma		Flavor		Aroma		Flavor		Aroma Intensity	
Source of Variation	Freedom	MS[1]	SE[2]	MS	SE	MS	SE	MS	SE	MS	SE
Replication (A)	5	2.53	0.09	1.09	0.13	2.06	0.08	0.96	0.12	0.74	0.07
Cooking Method (B)[3]	3	0.31	0.07	0.92	0.11	1.70	0.06	0.16	0.10	0.14	0.06
AB[4]	15	0.48		1.10		0.40		0.90		0.32	
Package Addition (C)	1	0.20	0.05	0.28	0.05	1.26	0.04	4.82	0.07	4.17	0.04
AC	5	0.15		0.85		0.57		2.70		0.25	
BC	3	1.67		0.26		0.87		0.04		0.16	
ABC	15	0.61		0.30		0.17		0.50		0.42	
(AC,ABC)[5]	20	0.49		0.44		0.27		1.05		0.38	
Panelist (D)	7	33.91	0.11	37.18	0.11	31.20	0.13	31.15	0.12	25.14	0.08
AD	35	1.14		0.83		1.20		0.97		0.43	
BD	21	0.44		0.81		0.95		0.76		0.39	
ABD	105	0.48		0.51		0.76		0.68		0.27	
CD	7	5.05		3.33		4.18		3.58		0.83	
ACD	35	0.71		0.49		0.79		0.49		0.39	
BCD	21	0.86		0.49		1.06		0.34		0.37	
ABCD	105	0.45		0.56		0.57		0.72		0.28	
(AD,ABD,ACD,ABCD)[6]	280	0.60(272df)		0.58(271df)		0.77(271df)		0.73(272df)		0.32(271df)	
Total	383										
Comparisons[7]											
C1 Treatment	1	0.29		2.71		0.94		0.19		0.13	
Error	5	0.46		2.24		0.47		1.84		0.12	
C2 Treatment	1	0.63		0.05		2.95		0.29		0.13	
Error	5	0.44		0.13		0.10		0.33		0.24	
C3 Treatment	1	0.03		1.00		0.28		0.47		0.26	
Error	5	0.56		1.33		0.14		1.21		0.11	
C4 Treatment	1	1.26		1.98		1.50		0.07		0.04	
Error	5	0.89		1.52		0.48		1.06		0.12	
C5 Treatment	1	0.67		0.04		2.04		0.30		0.01	
Error	5	0.42		0.27		0.19		0.31		0.56	
C6 Treatment	1	0.05		0.73		0.02		0.33		0.01	
Error	5	1.07		0.92		0.12		8.33		0.36	
C7 Treatment	1	0.14		0.84		0.02		0.12		0.51	
Error	5	0.29		0.99		0.17		0.90		0.16	
C8 Treatment	1	0.09		0.02		1.00		0.04		0.17	
Error	5	0.42		0.04		0.01		0.72		0.04	
C9 Treatment	1	0.23		0.32		0.37		0.15		0.63	
Error	5	0.10		0.61		0.09		0.67		0.14	
C10 Treatment	1	1.05		0.33		0.07		2.90		2.76	
Error	5	0.18		0.80		0.12		2.19		0.09	
C11 Treatment	1	2.22		0.15		3.23		1.40		0.38	
Error	5	0.42		0.37		0.41		1.06		0.20	
C12 Treatment	1	0.88		0.40		0.01		0.63		1.26	
Error	5	0.93		0.25		0.42		0.79		1.06	

Continued.

Table 21. Continued.

Source of Variation	Degrees of Freedom	Warmed-over Flavor Intensity MS[1]	SE[2]	Tenderness MS	SE	Juiciness MS	SE	Overall Acceptability MS	SE
Replication (A)	5	0.17	0.07	2.51	0.14	7.15	0.29	1.89	0.15
Cooking Method (B)[3]	3	0.24	0.06	6.92	0.11	6.64	0.24	1.42	0.12
AB[4]	15	0.36		1.22		5.34		1.36	
Package Addition (C)	1	7.04	0.04	0.00	0.04	25.83	0.10	4.29	0.07
AC	5	0.45		0.26		2.47		1.07	
BC	3	0.24		0.64		0.21		0.24	
ABC	15	0.24		0.40		1.49		1.07	
(AC,ABC)[5]	20	0.29		0.36		1.74		1.07	
Panelist (D)	7	34.61	0.07	40.59	0.10	15.59	0.10	15.27	0.13
AD	35	0.19		1.14		0.76		1.20	
BD	21	0.32		0.78		0.41		1.05	
ABD	105	0.18		0.50		0.44		0.83	
CD	7	1.01		0.40		0.36		3.91	
ACD	35	0.20		0.31		0.49		0.52	
BCD	21	0.17		0.26		0.33		0.45	
ABCD	105	0.29		0.33		0.36		0.67	
(AD,ABD,ACD,ABCD)[6]	280	0.23(271df)		0.51(272df)		0.47(270df)		0.80(271df)	
Total	383								
Comparisons[7]									
C1 Treatment	1	0.33		15.87		4.26		4.03	
Error	5	0.55		2.27		10.82		3.39	
C2 Treatment	1	0.02		0.02		5.40		0.00	
Error	5	0.32		0.71		2.40		0.27	
C3 Treatment	1	0.09		7.37		9.63		1.90	
Error	5	0.02		1.84		8.12		1.92	
C4 Treatment	1	0.09		10.80		1.35		1.71	
Error	5	0.29		1.76		8.12		2.53	
C5 Treatment	1	0.26		0.01		1.93		0.07	
Error	5	0.24		0.99		2.00		0.59	
C6 Treatment	1	0.02		5.74		3.26		0.54	
Error	5	0.23		1.94		5.04		1.54	
C7 Treatment	1	0.26		5.51		3.08		2.34	
Error	5	0.44		0.74		4.98		1.84	
C8 Treatment	1	0.09		0.09		3.60		0.03	
Error	5	0.37		0.12		1.02		0.73	
C9 Treatment	1	0.33		2.08		6.68		1.47	
Error	5	0.16		0.38		4.43		0.91	
C10 Treatment	1	2.76		0.05		13.13		1.92	
Error	5	0.19		0.06		1.75		1.94	
C11 Treatment	1	2.34		1.08		6.41		1.71	
Error	5	0.52		0.69		3.58		0.75	
C12 Treatment	1	2.04		0.67		6.30		0.77	
Error	5	0.24		0.37		1.34		0.88	

[1]Mean square
[2]Standard error
[3]SE estimated using AB interaction.
[4]Valid error term for testing significance of replication variation.
[5]Valid error term for testing significance of package addition variation.
[6]Valid error term for testing significance of panelist variation. One panelist (8df) missing for the third replication. Other values (0 to 2df) missing due to judges' oversights.
[7]See Figure 2, page 32, for descriptions of comparisons.

Table 22. Analyses of variance for trained taste panel data - frozen stored.

		Desirability				Beefy Intensity				Warmed-over	
	Degrees of	Aroma		Flavor		Aroma		Flavor		Aroma	
Source of Variation	Freedom	MS[1]	SE[2]	MS	SE	MS	SE	MS	SE	MS	SE
Replication (A)	5	0.76	0.07	1.23	0.08	1.28	0.10	2.82	0.11	0.44	0.06
Cooking Method (B)[3]	3	0.61	0.05	0.40	0.07	1.82	0.08	0.98	0.09	0.28	0.05
AB[4]	15	0.29		0.44		0.59		0.76		0.24	
Package Addition (C)	1	0.12	0.09	1.97	0.05	6.51	0.05	7.79	0.06	0.17	0.03
AC	5	0.39		1.57		0.04		1.33		0.11	
BC	3	1.07		0.39		2.57		3.00		0.06	
ABC	15	0.43		0.20		0.51		0.45		0.22	
(AC,ABC)[5]	20	0.42		0.54		0.39		0.67		0.19	
Panelist (D)	7	39.91	0.10	47.44	0.11	31.68	0.14	40.24	0.14	18.11	0.08
AD	35	0.75		1.40		1.76		1.81		0.71	
BD	21	0.28		0.72		0.56		1.55		0.35	
ABD	105	0.46		0.34		0.87		0.66		0.28	
CD	7	1.40		3.92		2.53		3.68		0.72	
ACD	35	0.33		0.59		1.09		1.15		0.16	
BCD	21	0.55		0.57		1.09		0.72		0.15	
ABCD	105	0.31		0.42		0.60		0.54		0.25	
(AD,ABD,ACD,ABCD)[6]	280	0.46(256df)		0.59(254df)		0.99(256df)		0.90(255df)		0.33(256df)	
Total	383										
Comparisons[7]											
C1 Treatment	1	0.32		0.57		2.50		1.98		0.22	
Error	5	0.26		0.28		0.80		0.74		0.25	
C2 Treatment	1	1.45		0.63		2.88		0.88		0.45	
Error	5	0.20		0.02		0.28		0.46		0.11	
C3 Treatment	1	1.56		1.20		5.37		2.75		0.65	
Error	5	0.05		0.22		0.44		0.44		0.23	
C4 Treatment	1	0.20		1.38		0.09		0.40		0.04	
Error	5	0.55		0.16		0.99		0.38		0.34	
C5 Treatment	1	0.02		0.24		2.04		3.96		0.04	
Error	5	0.21		0.06		0.64		0.14		0.27	
C6 Treatment	1	0.17		1.38		1.49		3.44		0.08	
Error	5	0.31		0.17		0.80		0.16		0.42	
C7 Treatment	1	0.12		0.01		3.76		1.84		0.21	
Error	5	0.05		0.19		0.49		0.99		0.17	
C8 Treatment	1	2.47		0.40		0.94		0.44		0.56	
Error	5	0.61		0.06		0.18		0.70		0.11	
C9 Treatment	1	1.84		0.14		4.23		0.24		0.73	
Error	5	0.31		0.15		0.53		1.08		0.14	
C10 Treatment	1	0.09		2.23		6.49		10.04		0.04	
Error	5	0.62		0.62		0.17		0.74		0.20	
C11 Treatment	1	0.92		0.05		2.91		4.73		0.00	
Error	5	0.40		0.52		0.44		0.22		0.26	
C12 Treatment	1	0.02		0.84		0.04		1.15		0.28	
Error	5	0.48		0.87		0.34		1.25		0.08	

Continued.

Table 22. Continued.

Source of variation	Degrees of Freedom	Warmed-over Flavor Intensity MS[1]	SE[2]	Tenderness MS	SE	Juiciness MS	SE	Overall Acceptability MS	SE
Replication (A)	5	0.77	0.04	0.01	0.11	3.95	0.11	3.25	0.07
Cooking Method (B)[3]	3	0.36	0.03	3.25	0.09	1.49	0.09	2.52	0.06
AB[4]	15	0.11		0.83		0.74		0.33	
Package Addition (C)	1	1.53	0.04	1.14	0.06	13.02	0.09	0.14	0.06
AC	5	0.17		0.94		3.88		1.38	
BC	3	0.05		0.33		0.30		0.11	
ABC	15	0.34		0.46		0.68		0.41	
(AC,ABC)[5]	20	0.29		0.58		1.48		0.65	
Panelist (D)	7	16.93	0.08	53.99	0.11	19.13	0.12	18.47	0.13
AD	35	0.82		0.96		1.15		2.17	
BD	21	0.29		1.20		0.73		1.33	
ABD	105	0.20		0.48		0.41		0.52	
CD	7	0.79		0.19		1.28		8.75	
ACD	35	0.21		0.57		1.06		0.89	
BCD	21	0.17		0.38		0.54		0.75	
ABCD	105	0.15		0.45		0.41		0.41	
(AD,ABD,ACD,ABCD)[6]	280	0.28(254df)		0.59(256df)		0.64(256df)		0.81(253df)	
Total	282								
Comparisons[7]									
C1 Treatment	1	0.97		6.20		3.74		5.92	
Error	5	0.04		0.28		0.23		0.54	
C2 Treatment	1	0.09		3.15		0.67		1.10	
Error	5	0.10		0.63		1.03		0.09	
C3 Treatment	1	0.83		9.10		3.78		6.05	
Error	5	0.12		0.41		0.45		0.31	
C4 Treatment	1	0.51		5.09		1.33		2.73	
Error	5	0.26		0.37		0.61		0.56	
C5 Treatment	1	0.00		1.53		1.17		1.28	
Error	5	0.05		0.61		1.16		0.09	
C6 Treatment	1	0.28		5.81		2.50		3.88	
Error	5	0.25		0.76		0.66		0.30	
C7 Treatment	1	0.46		1.60		2.50		3.19	
Error	5	0.35		0.49		0.35		0.32	
C8 Treatment	1	0.16		1.84		0.01		0.12	
Error	5	0.28		0.12		0.45		0.25	
C9 Treatment	1	0.58		3.44		1.37		2.28	
Error	5	0.57		0.14		0.17		0.32	
C10 Treatment	1	0.54		1.38		9.36		0.35	
Error	5	0.13		0.25		2.02		0.98	
C11 Treatment	1	0.24		0.09		1.73		0.02	
Error	5	0.35		0.34		1.16		0.18	
C12 Treatment	1	0.90		0.60		2.47		0.06	
Error	5	0.28		0.68		1.76		0.80	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition variation.
[6] Valid error term for testing significance of panelist variation. One panelist (8df) missing for the fifth and two panelists (16df) missing for the sixth replication. Other values (0 to 3 df) missing due to judges' oversights.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 23. Analyses of variance for trained taste panel data - fresh and frozen-stored.

Source of Variation	Degrees of Freedom	Desirability Aroma MS[1]	SE[2]	Desirability Flavor MS	SE	Beefy Intensity Aroma MS	SE	Beefy Intensity Flavor MS	SE	Warmed-over Aroma Intensity MS	SE
Replication (A)	5	2.46	0.06	1.09	0.09	2.83	0.06	2.35	0.09	0.12	0.06
Cooking Method (B)[3]	3	0.23	0.06	1.02	0.07	1.40	0.05	0.94	0.08	0.29	0.05
AB[4]	15	0.46		0.94		0.47		1.10		0.42	
Package Addition (C)	1	0.01	0.03	1.87	0.04	6.75	0.03	12.43	0.05	3.00	0.03
BC	3	2.47		0.59		2.55		1.88		0.17	
Storage Treatment (D)	1	15.22	0.03	9.61	0.04	48.30	0.03	30.04	0.05	1.02	0.03
BD	3	0.68		0.31		2.12		0.19		0.13	
CD	1	0.31		0.38		1.02		0.18		1.33	
BCD	3	0.27		0.06		0.89		1.16		0.05	
(AC,ABC,AD,ABD,ACD, ABCD)[5]	60	0.45		0.58		0.40		0.83		0.31	
Panelist (E)	7	72.12	0.07	80.97	0.08	59.99	0.10	68.96	0.09	42.45	0.06
BE	21	0.50		0.95		0.83		1.49		0.40	
CE	7	5.79		6.06		5.68		6.67		1.00	
BCE	21	0.98		0.46		1.57		0.67		0.42	
DE	7	1.71		3.65		2.89		2.43		0.80	
BDE	21	0.22		0.57		0.68		0.82		0.34	
CDE	7	0.66		1.19		1.04		0.59		0.55	
BCDE	21	0.42		0.59		0.59		0.40		0.09	
(AE,AEB,AEC,AEBC,AED, AEBD,AECD,AEBCD)[6]	560	0.53(528df)		0.59(525df)		0.88(527df)		0.81(527df)		0.33(527df)	
Total	767										
Comparisons[7]											
C13 Treatment	1	5.58		6.91		17.64		12.80		0.01	
Error	60	0.45		0.58		0.40		0.83		0.31	
C14 Treatment	1	9.95		3.08		31.68		17.43		2.34	
Error	60	0.45		0.58		0.40		0.83		0.31	
C15 Treatment	1	4.25		2.30		15.40		16.63		0.62	
Error	60	0.45		0.58		0.40		0.83		0.31	
C16 Treatment	1	4.20		4.14		11.95		5.43		0.73	
Error	60	0.45		0.58		0.40		0.83		0.31	
C17 Treatment	1	8.04		4.08		23.94		8.21		0.00	
Error	60	0.45		0.58		0.40		0.83		0.31	

Continued.

Table 23. Continued.

Source of Variation	Degrees of Freedom	Warmed-over Flavor Intensity MS[1]	SE[2]	Tenderness MS	SE	Juiciness MS	SE	Overall Acceptability MS	SE
Replication (A)	5	0.27	0.04	2.14	0.08	4.45	0.16	2.12	0.08
Cooking Method (B)[3]	3	0.46	0.04	8.77	0.06	6.32	0.13	3.46	0.07
AB[4]	15	0.24		0.79		3.22		0.85	
Package Addition (C)	1	7.57	0.03	0.61	0.04	37.76	0.08	3.00	0.05
BC	3	0.14		0.90		0.11		0.13	
Storage Treatment (D)	1	2.99	0.03	8.31	0.04	0.33	0.08	21.94	0.05
BD	3	0.14		1.40		1.82		0.48	
CD	1	1.00		0.53		1.09		1.44	
BCD	3	0.16		0.07		0.40		0.21	
(AD,ABC,AD,ABD,ACD, ABCD)[5]	60	0.31		0.75		2.34		1.04	
Panelist (E)	7	49.15	0.05	88.18	0.08	29.61	0.08	29.99	0.09
BE	21	0.36		1.19		0.55		1.67	
CE	7	1.03		0.48		1.33		10.94	
BCE	21	0.23		0.32		0.56		0.44	
DE	7	2.39		6.39		5.11		3.76	
BDE	21	0.25		0.78		0.59		0.71	
CDE	7	0.78		0.11		0.30		1.73	
BCDE	21	0.12		0.32		0.30		0.75	
(AE,AEB,AEC,AEBC,AED, AEBD,AECD,AEBCD)[6]	560	0.26(525df)		0.55(528df)		0.55(526df)		0.81(524df)	
Total	767								
Comparisons[7]									
C13 Treatment	1	0.27		6.51		0.11		17.30	
Error	60	0.31		0.75		2.34		1.04	
C14 Treatment	1	3.73		2.33		1.31		6.08	
Error	60	0.31		0.75		2.34		1.04	
C15 Treatment	1	1.53		0.69		0.01		9.44	
Error	60	0.31		0.75		2.34		1.04	
C16 Treatment	1	0.68		7.52		0.67		6.56	
Error	60	0.31		0.75		2.34		1.04	
C17 Treatment	1	0.79		3.41		4.32		6.06	
Error	60	0.31		0.75		2.34		1.04	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition and storage treatment variation.
[6] Valid error term for testing significance of panelist variation. One panelist (8df) missing for the third (fresh), one panelist (8df) missing for the fifth (frozen-stored), and two panelists (16df) missing for the sixth (frozen-stored) replications. Other values (0 to 4df) missing due to judges' oversights.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 24. Analyses of variance for TBA and shear force values - fresh or frozen-stored.

Source of Variation	Degrees of Freedom	Fresh TBA Values MS[1]	Fresh TBA Values SE[2]	Fresh Shear Force MS	Fresh Shear Force SE	Frozen-Stored TBA Values MS	Frozen-Stored TBA Values SE	Frozen-Stored Shear Force MS	Frozen-Stored Shear Force SE
Replication (A)	5	2.59	0.24	0.01	0.00	2.87	0.17	0.01	0.00
Cooking Method (B)[3]	3	1.44	0.20	0.00	0.00	0.88	0.14	0.01	0.00
AB[4]	15	0.95		0.00		0.44		0.00	
Package Addition (C)	1	3.16	0.12	0.01	0.00	0.28	0.11	0.00	0.00
AC	5	0.63		0.00		0.50		0.00	
BC	3	0.29		0.00		0.34		0.00	
ABC	15	0.77		0.00		0.56		0.00	
(AC,ABC)[5]	20	0.73		0.00		0.55		0.00	
Error[6]	48	0.13(35df)		0.00		0.14(40df)		0.00	
Total	95								
Comparisons[7]									
C1 Treatment	1	0.33		0.00		1.78		0.02	
Error	5	0.16		0.00		0.63		0.00	
C2 Treatment	1	0.17		0.00		0.04		0.00	
Error	5	0.93		0.00		0.15		0.00	
C3 Treatment	1	0.49		0.00		1.17		0.01	
Error	5	0.41		0.00		0.40		0.00	
C4 Treatment	1	0.05		0.00		0.10		0.02	
Error	5	0.23		0.00		0.36		0.00	
C5 Treatment	1	0.08		0.00		0.19		0.00	
Error	5	0.48		0.00		0.07		0.00	
C6 Treatment	1	0.00		0.00		0.28		0.01	
Error	5	0.24		0.00		0.12		0.00	
C7 Treatment	1	1.05		0.00		2.49		0.00	
Error	5	0.10		0.00		1.03		0.00	
C8 Treatment	1	0.09		0.01		0.03		0.00	
Error	5	0.68		0.00		0.39		0.00	
C9 Treatment	1	0.88		0.00		1.00		0.00	
Error	5	0.22		0.00		0.80		0.00	
C10 Treatment	1	2.86		0.00		0.08		0.01	
Error	5	0.33		0.00		0.31		0.00	
C11 Treatment	1	0.19		0.00		0.97		0.00	
Error	5	0.51		0.00		0.37		0.00	
C12 Treatment	1	0.54		0.01		0.23		0.00	
Error	5	1.21		0.00		0.72		0.00	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition variation.
[6] 13 (fresh) and 8 (frozen-stored) missing TBA values.
[7] See Figure 2, page 32, for descriptions of comparisons.

Table 25. Analyses of variance for TBA and shear force values - fresh and frozen-stored.

Source of Variation	Degrees of Freedom	TBA Values MS[1]	TBA Values SE[2]	Shear Force MS	Shear Force SE
Replication (A)	5	4.34	0.17	0.01	0.00
Cooking Method (B)[3]	3	2.04	0.14	0.01	0.00
AB[4]	15	0.92		0.00	
Package Addition (C)	1	0.78	0.08	0.00	0.00
AC	5	0.38		0.00	
BC	3	0.56		0.00	
ABC	15	0.99		0.00	
Storage Treatment (D)	1	0.14	0.08	0.00	0.00
AD	5	1.12		0.01	
BD	3	0.29		0.00	
ABD	15	0.47		0.00	
CD	1	2.66		0.01	
ACD	5	0.75		0.00	
BCD	3	0.07		0.00	
ABCD	15	0.33		0.00	
(AC,ABC,AD,ABD,ACD, ABCD)[5]	60	0.64		0.00	
Error[6]	96	0.11(75df)		0.00	
Total	191				
Comparisons[7]					
C13 Treatment	1	0.78		0.01	
Error	60	0.64		0.00	
C14 Treatment	1	2.02		0.00	
Error	60	0.64		0.00	
C15 Treatment	1	0.01		0.01	
Error	60	0.64		0.00	
C16 Treatment	1	0.89		0.00	
Error	60	0.64		0.00	
C17 treatment	1	0.00		0.00	
Error	60	0.64		0.00	

[1]Mean square
[2]Standard error
[3]SE estimated using AB interaction.
[4]Valid error term for testing significance of replication variation.
[5]Valid error term for testing significance of package addition and storage treatment variation.
[6]21 missing TBA values.
[7]See Figure 2, page 32, for descriptions of comparisons.

Table 26. Analyses of variance for water holding capacity values - fresh or frozen-stored.

Source of variation	Degrees of Freedom	Water Holding Capacity: Fresh MS[1]	Fresh SE[2]	Frozen-Stored MS	Frozen-Stored SE
Replication (A)	5	0.01	0.02	0.08	0.04
Cooking Method (B)[3]	3	0.01	0.02	0.00	0.03
AB[4]	15	0.01		0.03	
Package Addition (C)	1	0.05	0.01	0.13	0.01
AC	5	0.01		0.01	
BC	3	0.00		0.00	
ABC	15	0.01		0.02	
(AC,ABC)[5]	20	0.01		0.02	
Error	96	0.00		0.00	
Total	143				
Comparisons[6]					
C1 Treatment	1	0.01		0.01	
Error	5	0.01		0.02	
C2 Treatment	1	0.00		0.00	
Error	5	0.01		0.04	
C3 Treatment	1	0.00		0.00	
Error	5	0.01		0.04	
C4 Treatment	1	0.01		0.00	
Error	5	0.02		0.03	
C5 Treatment	1	0.00		0.01	
Error	5	0.01		0.03	
C6 Treatment	1	0.01		0.00	
Error	5	0.01		0.04	
C7 Treatment	1	0.00		0.00	
Error	5	0.00		0.02	
C8 Treatment	1	0.00		0.00	
Error	5	0.01		0.02	
C9 Treatment	1	0.00		0.01	
Error	5	0.00		0.02	
C10 Treatment	1	0.03		0.09	
Error	5	0.02		0.02	
C11 Treatment	1	0.00		0.03	
Error	5	0.01		0.02	
C12 Treatment	1	0.02		0.02	
Error	5	0.01		0.01	

[1] Mean square
[2] Standard error
[3] SE estimated using AB interaction.
[4] Valid error term for testing significance of replication variation.
[5] Valid error term for testing significance of package addition variation.
[6] See Figure 2, page 32, for descriptions of comparisons.

Table 27. Analyses of variance for water holding capacity values - fresh and frozen-stored.

Source of Variation	Degrees Freedom	Water Holding Capacity MS[1]	SE[2]
Replication (A)	5	0.07	0.02
Cooking Method (B)[3]	3	0.01	0.02
AB[4]	15	0.03	
Package Addition (C)	1	0.17	0.01
AC	5	0.01	
BC	3	0.00	
ABC	15	0.02	
Storage Treatment (D)	1	1.00	0.01
AD	5	0.02	
BD	3	0.00	
ABD	15	0.01	
CD	1	0.01	
ACD	5	0.00	
BCD	3	0.00	
ABCD	15	0.01	
(AD,ABC,AD,ABD,ACD, ABCD)[5]	60	0.01	
Error	192	0.00	
Total	287		
Comparisons[5]			
C13 Treatment	1	0.61	
Error	60	0.01	
C14 Treatment	1	0.40	
Error	60	0.01	
C15 Treatment	1	0.48	
Error	60	0.01	
C16 Treatment	1	0.24	
Error	60	0.01	
C17 Treatment	1	0.27	
Error	60	0.01	

[1]Mean square
[2]Standard error
[3]SE estimated using AB interaction.
[4]Valid error term for testing significance of replication variation.
[5]Valid error term for testing significance of package addition and storage treatment variation.
[6]See Figure 2, page 32, for descriptions of comparisons.

Table 28. Analyses of variance for consumer panel scores for palatability characteristics of frozen stored "ready-prepared" roast beef bulk packaged in gravy.

Source of Variation	Degrees of Freedom	Appearance[1]		Flavor		Tenderness		Juiciness		Temperature		Overall Acceptability	
		MS[2]	SE[3]	MS	SE	MS	SE	MS	SE	MS	SE	MS	SE
Replication[4]	5	0.61		1.02		1.76		1.89		0.92		0.53	
Comparisons[5]													
C1 Treatment	1	0.18	0.11	1.06	0.14	3.46	0.26	0.04	0.24	0.18	0.06	0.06	0.25
Error	5	0.36		0.56		1.97		1.73		0.10		1.86	
C2 Treatment	1	0.93	0.10	1.22	0.15	3.97	0.15	9.76	0.14	0.41	0.09	2.67	0.16
Error	5	0.25		0.53		0.51		0.45		0.18		0.61	
C3 Treatment	1	1.00	0.21	0.02	0.18	7.42	0.30	6.01	0.26	0.58	0.13	1.11	0.31
Error	5	0.55		0.44		1.20		0.88		0.22		1.24	
Within cells	230	0.57		0.71		1.50		1.25		0.68		0.78	

[1]Degrees of freedom for "within cells" = 226 for appearance due to missing data.

[2]Mean square

[3]Standard error

[4]Not tested.

[5]See Figure 2, page 32, for descriptions of comparisons.

Figure 8. Specifications for equipment and materials used in the study.

Category	Item	Source	Miscellaneous	Use
Cooking/ reheating	rotary gas oven -model 5-26 110	Nicholson Equipment Ltd., Vancouver, B.C.	-1360 kg capacity -temp: 177° -five shelves -1 rev/80 sec	-cooking roasts by CONV method
	hot-water bath -model 66802	Precision Scientific Co., Chicago, Ill.	-volume: 36 L -water temp: 61° -thermostatically controlled -equipped with motor for water circulation	-cooking roasts by WB method
	Alto-Shaam oven -Thunderbolt, model 750-TH-II	Alto-Shaam Inc., Menomonee Falls, Wis.	-54.5 kg capacity -temp: 107° -high humidity (95 - 100%) generated during cooking	-cooking roasts by AS method
	household electric range -Kenmore Mark 3	Canadian Appliance Manufacturing Corp. (CAMCO), Ont.	-oven temp: 177° -top of stove: high heat	-oven: baking ground beef loaves for taste panel anchors -top of stove: GR preparation
	forced-air convection oven -model X-L300	Baker's Pride Canada Ltd., Lachine, Que.	-temp: 177°	-reheating IND packages of cooked, sliced beef
	-model M2600	Market Forge, Everett, Mass	-temp: 177°	-reheating BLK GR packages of cooked, sliced beef
Slicing	automatic slicer -model 1836	Berkel Products Co., Ltd., Toronto, Ont.	-slice thickness variable; set to 3 and 4 mm -guard removable for blade cleaning	-slicing cooked roasts -slicing ground beef loaves for taste panel anchors

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Packaging	polyethylene gusset bags -type No. 15	Polyrama Plastics Ltd., Edmonton, Alta.	-dimensions: 356 x 559 mm	-packaging raw roasts for freezing -packaging whole, cooked roasts for chilling
	plain bags -type No. S 510	Cryovac Division, W.R. Grace and Co. of Canada Ltd., Mississauga, Ont.	-dimensions: 330 x 229 mm	-vacuum packaging raw ground beef loaves (taste panel anchors) for freezing
	cooking bags -type L600	Cryovac Division, W.R. Grace and Co. of Canada Ltd., Mississauga, Ont.	-partial vacuum drawn -sealed with twister -bag opening end not immersed -material: shrinkable, cross-linked, balanced, biaxially oriented polyolefin	-roast inserted into bag for cooking by WB method
	tray former and lid sealer -Traytite® HS-H double head hot air erector and ES sealer	Sprinter Systems, Halmstad, Sweden (supplied by Somerville Belkin Industries Ltd.)	-packages microwave sealed	-forming Traytite® (IND) packages -sealing Traytite® packages for FZN-S treatments (after filling and LCO_2 freezing)
	bulk aluminum foil packages -code No. 788-35	Ecko Canada Ltd.	-volume: 1 L -dimensions (top): 214 x 151 x 46 mm -guage: 0.089 mm	-packaging cooked, sliced beef for BLK GR FZN-S treatments
	individual (IND) packages -Traytite® "S"	Somerville Belkin Industries Ltd., Toronto, Ont.	-dimensions (top): 130 x 110 x 40 mm -material: paperboard, Polyethylene Terephtalate (PET) laminated claycoated solid bleached sulphite	-packaging cooked, sliced beef for IND FSH and IND FZN-S (GR and GLZ) treatments

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Packaging (continued)	all-purpose aluminum foil	Alcan Canada Products Ltd., Toronto, Ont.	-width: 30 cm	-sealing IND FSH packages of cooked, sliced beef -sealing BLK FZN-S packages of cooked, sliced beef
Chilling	refrigerator -Frigidaire	General Motors Inc.	-temp: 4°	-thawing raw roasts (first 48 h)
	-model RSCP-48	Coldstream Products of Canada Ltd., Winnepeg, Man.	-temp: 2°	-thawing raw roasts (last 39 h) -thawing raw ground beef loaves (taste panel anchors) -chilling prepared GR and GLZ
	-Frigidaire	General Motors Inc.	-temp: 2°	-chilling cooked roasts
Freezing	liquid carbon dioxide (LCO_2) freezing system -Kryospray, model 4150	Cryo-Chem Inc., Gardena, Cal.	-temp: -60° -tunnel speed: IND packages: 2½ BLK packages: 1½	-quick initial freezing of IND and BLK packages of cooked, sliced beef.
	walk-in storage freezer -Home Economics Building	Hussman Brantford, Ont.	-temp: -25°	-storage of raw roasts -storage of IND and BLK packages of beef -storage of vacuum-packaged, raw ground beef loaves (taste panel anchors)
	-Industrial Services Center (ISC) - Forward Hold Freezer	Foster	-temp: -15 ± 3°	-two-hour interim storage of IND and BLK packages of cooked, sliced beef after LCO_2 freezing

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Temperature monitoring	recording potentiometer with attached copper constantan thermocouples	Honeywell Industrial Division, Scarborough, Ont.		
	-model 15206826-12-43-2-000-018-11		-temp range: 0° to 150°	-internal temp during cooking of AS roasts -internal temp during re-heating of IND packages of cooked beef
	-model 153x85-C6S-II-III-87		-temp range: 0° to 150°	-post-oven internal temp rise of CONV roasts -internal temp during re-heating and warm-holding of BLK GR packages of beef
	-model 15305836-12-07-2-000-002-10-060-202-004		-temp range: -50° to 250°	-temp cycles of AS oven and Baker's Pride convection oven -internal temp during cook-ing of WB roasts -hot-water bath temp -internal temp during chil-ling of cooked roasts -refrigerator temp cycles
	digital probe thermometer -probe type HT-1	Bailey Instruments, Inc., Saddle Brook, NJ		-center temp of IND and BLK packages of beef before and after LCO_2 freezing -room temp -temp of storage freezers and refrigerators -temp of beef samples as served to trained panel -temp of double-boiler water during warm holding of samples for trained panel

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Temperature monitoring (continued)	glass mercury thermometer	Fisher scientific Co., Ltd., Toronto, Ont.	-temp range: -20 to 105° -length: 14 cm	-internal temp during cooking of CONV roasts -internal temp during baking of ground beef loaves (taste panel anchors)
			-temp range: -10 to 260° -length: 40 cm	-temp of GR during preparation
	oven thermometer -model 5973FC	Taylor Instruments Ltd., Toronto, Ont.	-temp range: 100 to 250°	-temp of rotating gas oven during cooking of CONV roasts
Objective and analytical analyses	single-pan balance -type 2353SC408	Sartorius-Werke GMBH, Gottingen, Germany	-maximum, 5000 g -to 0.1 g	-cooking and chilling loss and pH determinations
	-type 2253-47165		-maximum, 3000 g -to 0.1 g	-Kramer shear tests
	-model P(K) 162	Mettler Instruments AG, Zurich, Switzerland	-maximum, 160 g -to 0.001 g	-TBA tests -fat and moisture determinations
	-model P(K) 1200		-maximum, 1200 g -to 0.01 g	-fat and moisture determinations
	double-pan balance -model 1119	Chaus Union, NJ	-maximum, 20 kg -to 1 g	-cooking and chilling loss determinations
	analytical balance -Gram-atic	Mettler Instruments AG, Zurich, Switzerland.	-maximum, 1000 g -to 0.0001 g	-WHC determinations
	blender/grinder	Moulinex	-blending time: 60 sec -blending time: 90 sec -blending time: 20 sec	-pH determinations -TBA tests -fat and moisture determinations

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Objective and analytical analyses (continued)	pH/ion meter -Accumet, model 230	Fisher Scientific Co., Ltd., Toronto, Ont.		-pH determinations
	freeze drier	Lab Con Co., Kansas City, Miss.	-temp: $<$ -50° -pressure: $<$ 100 microns	-fat and moisture determinations
	drying oven -model 625	Precision Scientific Co., Chicago, Ill.	-temp: 105°	-fat and moisture determinations
	Goldfisch apparatus	Lab Con Co., Kansas City, Miss	-two models, six burners each	-fat (ether extract) determinations
	Carver press -model C	Fred S. Carver Inc., Menomonee Falls, Wis.	-sample weight: 0.5 g -pressure: 878.8 kg/cm² -time under pressure: 60 sec	-WHC determinations
	compensating planimeter -model 349-1838	Hugh-Owens		-WHC determinations - measuring areas of pressed meat and fluid imprinted on filter paper
	Kjeldahl apparatus	Precision Scientific Co., Chicago, Ill.	-12 burners -10 min distillation	-TBA tests
	UV spectrophotometer -SP 1800	Pye Unicam	-wavelength: 532 nm	-TBA tests
	Ottawa Texture Measuring System (OTMS) - Kramer Shear compression cell	Engineering Research Services, Research Branch, Agriculture Canada, Ottawa, Ont.	-30 sec downstroke -100% range selection -force=kilograms/gram	-shear force determinations
Vacuum drawing	vacuum -model 640-72	Shop-Vac (Canada) Ltd., Toronto, Ont.	-sanitary tubing attached	-drawing partial vacuum in WB roast cooking bags -vacuum packaging raw ground beef loaves (taste panel anchors) for freezing

Continued.

Figure 8. Continued.

Category	Item	Source	Miscellaneous	Use
Transport	styrofoam insulated containers	Morval Deluxe, Canada	-dimensions (top): 51.5 x 33 x 30 cm -thickness: 2.5 cm	-transporting whole raw, whole cooked and cooked, sliced beef between the ISC and Home Economics building
Sensory evaluations	MacBeth skylight -model BBX826	MacBeth Color and Photometry Division, Kollmorgen Corp., Newburgh, NY	-set to daylight	-slice evaluation
	HotraysⓉ -model H-907, H-120, H-928 and H-920	Salton MFG. CC., New York, NY	-set on high heat	-maintaining double-boiler water warm (85°) during holding of samples for trained taste panel
	HotablesⓉ -model H-958-W and H-156-W		-set on high heat	
	casserole dishes -type P-1-B	Corning Glassworks of Canada Ltd., Toronto, Ont.	-volume: 900 mL -two casserole dishes nested to form double boilers -400 mL water (85°) in bottom casserole dish	-maintaining samples warm (50°) during evaluation by trained taste panel
	custard cups with glass sealer lids -type 462	Pyrex® U.S.A.	-volume: 140 mL -coded with three-digit random numbers -two or three custard cups placed in one double boiler	-containing individual, warm samples for service to trained taste panel
	mobile hot serving unit -model 99148	Vollrath, Rexdale, Ont.	-set on low heat	-maintaining BLK GR FZN-S samples warm (70 to 80°) during service to consumer taste panel

Figure 9 . Experiment flow chart.

Experiment half	Week	Replication	Day	Steps conducted[1]
I	1, 2 & 3	1 to 6	1	- cooking and chilling whole roasts - some objective analyses on whole roasts (pH, thaw loss physical measurements, cooking losses and cooking times)
			2	- sectioning and slicing cooked roasts - packaging samples (IND and BLK, GR and/or GLZ) for FSH and FZN-S treatments - subjective and objective evaluations of FSH treatments - LCO_2 freezing FZN-S (IND and BLK, GR and/or GLZ) treatments - start of frozen storage periods: IND FZN-S treatments: 20 to 21 days BLK FZN-S treatments: average of 14 days
II	4, 5 & 6	1 to 6	3	- some objective analyses (TBA and WHC) on IND FZN-S treatments - consumer evaluation of BLK GR FZN-S treatments[2]
			4	- subjective and objective evaluations on IND FZN-S treatments

[1] See Figure 1, page 30 for descriptions of treatment abbreviations.

[2] BLK GR FZN-S treatments were evaluated by a consumer taste panel on one occasion only.

Table 29. Animal[1] age, weight and biceps femoris muscle weight statistics for the study.

	Mean	Range
Age (years)	2.47	1.92 to 3.07
Live weight (kg)	537.12	426 to 647
Warm carcass weight (kg)	289.79	232 to 356
Muscle weight (kg)	4.64	3.69 to 5.86

[1]Breeds - 19 Beef Synthetic sides (6 cripple herd) and 5 Dairy Crossbred sides

(Animal breed composition included Angus, Brownin, Brown Swiss, Charolais, Galloway, Hereford, Holstein and Simmental.)

Figure 10. Slice evaluation scorecard for the appearance of "ready-prepared" roast beef.

Judge ____________

Date ____________

Sample No. ____________

	5	4	3	2	1
COLOR (If you score 3 or less, explain why.)	very good	good	neither good nor poor	poor	very poor
GRAIN	fine	good	fair to good	slightly coarse	very coarse
DEGREE of DONENESS	medium (pinkish)				well-done (very brown)
					rare (red)
UNIFORMITY of DONENESS	same degree of doneness throughout slice		more well-done around edge than in center of slice		marked ring effect
OVERALL APPEARANCE (If you score 3 or less, explain why.)	very desirable	desirable	neither desirable nor undesirable	undesirable	very undesirable

COMMENTS:

Figure 11. Instructions for sensory evaluation of sliced roast beef.

For each palatability characteristic listed on the scorecard, rate each roast beef sample according to the seven-point scale provided. Do this by placing a "✓" in the appropriate box containing the descriptive words which best describe your impression of the sample. Evaluate each sample individually, trying <u>not</u> to make comparisons between samples. If you assign a score of 3 or less to a particular sample, where applicable please explain why in the COMMENTS section of the scorecard.

Then, look at the list of terms suggested at the bottom of the scorecard and check the term or terms that <u>describe</u> your impressions of the aroma and flavor of the sample.

<u>AROMA</u> - Lift the lid, immediately place the beef sample directly under your nose and breath in <u>three</u> times. Then, using the seven-point scale, score the sample for desirability of aroma. Then, rate the sample for intensity of "warmed-over" aroma. An anchor has been provided to help you standardize your scores for "warmed-over" aroma; this should be smelled <u>three</u> times <u>before</u> smelling the test sample of roast beef. Finally, score the sample of beef for intensity of beefy aroma.

<u>JUICINESS</u> - Juiciness refers to your impression of the moistness of the sample after <u>five</u> chews. An anchor has been provided to standardize juiciness scores. Chew the anchor five times. Then, place one square of beef in your mouth so you are biting down into the flat surface of the slice, chew <u>five</u> times and evaluate the sample for juiciness according to the seven-point scale.

<u>TENDERNESS</u> - Continue chewing the meat sample or take a second square of sample and place it in your mouth so you are biting down into the flat surface of the slice. Count the number of chews required to completely masticate the sample and record this number on your scorecard. Then refer to your chew range card and score the sample for tenderness according to the seven-point scale.

<u>FLAVOR</u> - Flavor is your impression of the beef sample after continued chewing. Chew the sample until it is completely masticated. Then, record your impressions of the desirability of the flavor, the intensity of "warmed-over" flavor and the intensity of beefy flavor of the sample according to the seven-point scale provided. An anchor has been provided to standardize scores for "warmed-over" flavor intensity. Taste a square of the anchor <u>before</u> tasting and scoring the test sample of beef for intensity of "warmed-over" flavor. There is no need to swallow the anchor if you do not wish to do so.

<u>OVERALL ACCEPTABILITY</u> - Overall acceptability refers to your overall impression of the desirability of the sample and, like the other palatability characteristics, is evaluated on the seven-point scale.

<u>COMMENTS</u> - Your comments about the sample are welcome and would be very helpful. In addition, use this section of the scorecard, where applicable, to give reasons for assigning a score of 3 or less for a particular palatability characteristic.

<u>FLAVOR CARRYOVER PREVENTION</u> - Be sure to rinse your mouth with water between tasting samples as well as after tasting anchors in order to eliminate flavor carryover. Unsalted crackers have also been provided for this purpose.

<u>NOTE</u>:

- When using the seven-point rating scale to evaluate a sample, keep in mind the descriptive terminology listed under each score from 1 to 7.
- You are not required to swallow the beef samples tasted for evaluating juiciness and flavor, nor is it necessary to swallow anchors.
- Before leaving your booth, check to ensure that you have completed the <u>entire</u> scorecard.

THANKYOU !

Figure 12. Trained taste panel scorecard for evaluation of "ready-prepared" roast beef.

For each characteristic, put a check (✓) in the box containing the description which best describes the sample. If you score 3 or less, please explain why in the COMMENTS section of the scorecard.

Judge ________

Date ________

Sample No:

		7	6	5	4	3	2	1
AROMA	Desirability	very desirable	desirable	slightly desirable	neither desirable nor undesirable	slightly undesirable	undesirable	very undesirable
	Intensity of warmed-over aroma	not detectable	very slight	slight	moderate	strong	very strong	extremely strong
	Intensity of beefy aroma	very beefy	beefy	slightly beefy	neither beefy nor weak	slightly weak	weak	very weak
JUICINESS (5 chews)		very juicy	juicy	slightly juicy	neither juicy nor dry	slightly dry	dry	very dry
TENDERNESS	No. of chews = ________							
		very tender	tender	slightly tender	neither tender nor tough	slightly tough	tough	very tough
FLAVOR	Desirability	very desirable	desirable	slightly desirable	neither desirable nor undesirable	slightly undesirable	undesirable	very undesirable
	Intensity of warmed-over flavor	not detectable	very slight	slight	moderate	strong	very strong	extremely strong
	Intensity of beefy flavor	very beefy	beefy	slightly beefy	neither beefy nor weak	slightly weak	weak	very weak
OVERALL ACCEPTABILITY		very acceptable	acceptable	slightly acceptable	neither acceptable nor unacceptable	slightly unacceptable	unacceptable	very unacceptable

Descriptive terms: (Check the term or terms that apply.)

AROMA
- fresh
- beefy
- brothy
- bouillon-like (artificial)
- weak
- warmed-over (stale, old)
- rancid
- metallic
- sweet
- acidic
- burnt (acrid)
- fishy
- livery
- oniony
- peppery
- spicy

FLAVOR
- fresh
- beefy
- brothy
- bouillon-like (artificial)
- weak (bland)
- warmed-over (stale, old)
- rancid
- metallic
- sweet
- acidic (sour)
- burnt (acrid)
- fishy
- livery
- oniony
- peppery
- salty
- bitter
- astringent
- cardboardy (papery)
- spicy

COMMENTS (Use other side of sheet if you wish):

Figure 13. Method of preparation of anchor used to standardize trained taste panel scores for warmed-over aroma and flavor.

Individual 250 g loaves were formed from a 7 kg uniformly mixed lot of ground beef (18% fat and 63% moisture), placed in aluminum foil loaf pans (15.5 x 9.0 x 5.0 cm), vacuum packaged in Cryovac® bags, frozen and stored (-25°) for two to eight weeks.

The ground beef samples used to anchor taste panel scores for intensity of WOA and WOF were prepared in the same way before each tasting session. One ground beef loaf was defrosted (2°) for 24 h and heated in a household electric oven (Kenmore, Mark 3) (177°) to an internal temperature of 72° (monitored with a Fisher glass thermometer). The loaf was cooled at room temperature (23 ± 1°) to 50°, the drip was drained off and the loaf was cut, crosswise, into 5 mm thick slices. The slices were placed in a single layer on a glass plate, covered loosely with a second plate, cooled at room temperature for a further 30 min, then stored (2°) for 22 h.

Each panelist received two slices (2 cm x 2 cm x 5 mm) of ground beef loaf in a 50 mL beaker covered with a watch-glass. The ground beef anchor was warmed for 10 min over hot water (85°) and presented to the judges warm (50°) with their first set of samples at each tasting session.

Figure 14. Consumer panel scorecard for evaluation of "ready-prepared" roast beef.

Date ______

Rate each of the two samples of roast beef for each characteristic listed by placing the number of your score from 1 to 5 in the box under the appropriate sample number. Then, for each sample, check, in the appropriate box, the flavor description which best describes your impression of the flavor of the sample.

Characteristic	5	4	3	2	1	Sample No.	
APPEARANCE	very desirable	desirable	neither desirable nor undesirable	undesirable	very undesirable		
TENDERNESS	tender	slightly tender	neither tender nor tough	slightly tough	tough		
JUICINESS	juicy	slightly juicy	neither juicy nor dry	slightly dry	dry		
FLAVOR	very desirable	desirable	neither desirable nor undesirable	undesirable	very undesirable		
TEMPERATURE	very acceptable	acceptable	neither acceptable nor unacceptable	unacceptable	very unacceptable		
OVERALL ACCEPTABILITY	very acceptable	acceptable	neither acceptable nor unacceptable	unacceptable	very unacceptable		
			FLAVOR DESCRIPTIONS:	1. beefy 2. weak (bland) 3. bouillon-like (artificial) 4. warmed-over (stale, old)			

VOLUNTARY INFORMATION:

Sex: Male ___ Female ___

Age: under 18 ___ 19-25 ___ 26-35 ___ 36-50 ___ 51-65 ___

Your COMMENTS or SUGGESTIONS are very welcome:
(Use the other side of sheet if you wish.)

Table 30. Means and F-values for Comparisons C4 to C9[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional, water bath and Alto-Shaam methods and packaged in gravy and carrageenan glaze - frozen-stored[2].

	GR							GLZ					
	Cooking Method				F-value							F-value	
Measurements	CONV-1	WB	CONV-2	AS	C4	C5	C6	CONV-1	WB	CONV-2	AS	C7	C8	C9
Subjective														
Slice evaluation[3]														
Overall appearance	3.2	3.3	3.2	3.4	0.14	0.49	0.13	3.1	2.8	3.1	2.9	2.95	0.28	0.04
Color	3.3	3.4	3.2	3.5	0.16	1.91	0.23	3.3	3.0	3.2	3.2	1.09	0.07	0.10
Grain	3.6	3.7	3.5	3.4	0.00	3.46	0.46	2.6	2.5	2.6	2.4	0.40	0.65	0.07
Degree of doneness	3.1	3.4	2.8	2.9	1.14	0.17	0.09	3.3	3.2	3.0	2.7	0.39	0.50	0.26
Uniformity of doneness	3.6	3.8	3.6	3.9	1.93	1.88	0.02	3.9	3.9	4.0	3.8	0.00	0.65	0.21
Trained taste panel[4]														
Desirability of - aroma	5.1	5.1	5.0	5.0	0.37	0.09	0.54	4.9	5.0	5.2	4.9	2.22	4.05	6.03
- flavor	4.7	5.0	4.8	4.7	8.42*	3.76	8.12*	4.9	4.9	5.1	4.9	0.06	7.17*	0.94
Intensity of beefy - aroma	4.8	4.8	4.7	4.4	0.09	3.21	1.86	4.1	4.5	4.6	4.4	7.75*	5.34	8.03*
- flavor	4.8	5.0	4.9	4.5	1.06	28.17**	21.58**	4.3	4.5	4.6	4.7	1.86	0.63	0.22
Intensity of warmed-over - aroma	6.5	6.6	6.6	6.5	0.12	0.16	0.20	6.5	6.6	6.6	6.4	1.27	5.06	5.36
- flavor	6.6	6.7	6.7	6.7	1.96	0.02	1.12	6.5	6.6	6.6	6.5	1.32	0.57	1.02
Tenderness	4.4	4.9	4.6	4.4	13.90*	2.16	7.69*	4.5	4.8	4.8	4.5	3.25	15.54*	23.95**
Juiciness	3.6	3.8	3.8	3.6	2.16	1.00	3.81	3.2	3.6	3.3	3.3	7.13*	0.01	7.84*
Overall acceptability	4.4	4.7	4.7	4.5	4.88	14.52*	13.09*	4.3	4.7	4.6	4.5	9.98*	0.49	7.21*
Objective														
TBA value (mg malonaldehyde/kg)[5]	1.7	1.6	1.3	1.5	0.27	2.73	2.26	1.8	1.2	1.4	1.3	2.42	0.07	1.25
Shear force (kg/g)[5]	0.28	0.23	0.28	0.27	10.29*	6.13	5.52	0.27	0.25	0.25	0.25	0.68	0.03	0.41
Water holding capacity[6]	0.37	0.39	0.37	0.40	0.12	0.20	0.00	0.43	0.45	0.46	0.44	0.21	0.22	0.38

[1] See Figure 2, page 32, for descriptions of comparisons.
[2] See Figure 1, page 30, for descriptions of treatment abbreviations.
[3] Maximum score, 5. Values are the means of 24 judgements, one per replication by each of four panelists.
[4] Maximum score, 7. Values are the means of 48 judgements, one per replication by each of eight panelists.
[5] Values are the means of 12 determinations, two per replication.
[6] Values are the means of 18 determinations, three per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

Table 31. Means and F-values for Comparisons C10, C11 and C12[1] for subjective and objective data on "ready-prepared" roast beef cooked by the conventional institution, water bath and Alto-Shaam methods and packaged in gravy and carrageenan glaze - frozen-stored[2].

	C10			C11			C12		
	CONV-1 & -2			WB			AS		
Measurements	GR	GLZ	F-value	GR	GLZ	F-value	GR	GLZ	F-value
Subjective									
Slice evaluation[3]									
Overall appearance	3.2	3.1	0.35	3.3	2.8	8.57*	3.4	2.9	7.15*
Color	3.3	3.3	0.00	3.4	3.0	6.71*	3.5	3.2	3.37
Grain	3.6	2.6	56.62**	3.7	2.5	11.52*	3.4	2.4	55.00**
Degree of doneness	2.9	3.1	0.59	3.4	3.2	3.46	2.9	2.7	4.81
Uniformity of doneness	3.6	3.9	3.86	3.8	3.9	0.13	3.9	3.8	0.18
Trained taste panel[4]									
Desirability of - aroma	5.0	5.1	0.15	5.1	5.0	2.33	5.0	4.9	0.05
- flavor	4.8	5.0	3.62	5.0	4.9	0.10	4.7	4.9	0.97
Intensity of beefy - aroma	4.7	4.3	38.34**	4.8	4.5	6.61*	4.4	4.4	0.12
- flavor	4.9	4.4	13.54*	5.0	4.5	21.92**	4.5	4.7	0.92
Intensity of warmed-over - aroma	6.5	6.5	0.18	6.6	6.6	0.00	6.5	6.4	3.40
- flavor	6.6	6.5	4.25	6.7	6.6	0.68	6.7	6.5	3.17
Tenderness	4.5	4.7	5.61	4.9	4.8	0.28	4.4	4.5	0.89
Juiciness	3.7	3.3	4.64	3.8	3.6	1.50	3.6	3.3	1.40
Overall acceptability	4.5	4.4	0.36	4.7	4.7	0.13	4.5	4.5	0.07
Objective									
TBA value (mg malonaldehyde/kg)[5]	1.5	1.6	0.27	1.6	1.2	2.64	1.5	1.3	0.31
Shear force (kg/g)[5]	0.28	0.26	6.16	0.23	0.25	0.99	0.27	0.25	12.32*
Water holding capacity[6]	0.37	0.44	3.79	0.39	0.45	1.48	0.40	0.44	1.33

[1] See Figure 2, page 32, for descriptions fo comparisons.
[2] See Figure 1, page 30, for descriptions of treatment abbreviations.
[3] Maximum score, 5. Values are the means of 48 (CONV-1 and -2) or 24 (WB or AS) judgements, one per replication by each of four panelists.
[4] Maximum score, 7. Values are the means of 96 (CONV-1 and -2) or 48 (WB or AS) judgements, one per replication by each of eight panelists.
[5] Values are the means of 24 (CONV-1 and -2) or 12 (WB or AS) determinations, two per replication.
[6] Values are the means of 36 (CONV-1 and -2) or 18 (WB or AS) determinations, three per replication.

* Significant at $P < 0.05$
** Significant at $P < 0.01$

Table 32. Means and F-values for subjective and objective data on "ready-prepared" roast beef - fresh and frozen-stored.

Measurements		Storage Treatment[1] FSH	FZN-S	F-value
Subjective				
Slice evaluation[2]				
Overall appearance		3.4	3.1	6.26*
Color		3.5	3.3	5.83*
Grain		3.5	3.0	24.41**
Degree of doneness		3.4	3.0	9.16*
Uniformity of doneness		3.9	3.8	0.63
Trained taste panel[3]				
Desirability of	- aroma	5.3	5.0	33.85**
	- flavor	5.1	4.9	16.59**
Intensity of beefy	- aroma	5.0	4.5	121.97**
	- flavor	5.1	4.7	36.10**
Intensity of warmed-over	- aroma	6.5	6.5	3.27
	- flavor	6.5	6.6	9.66**
Tenderness		4.8	4.6	11.14**
Juiciness		3.5	3.5	0.14
Overall acceptability		4.9	4.5	21.18**
Objective				
TBA value (mg malonaldehyde/kg)[4]		1.5	1.5	0.23
Shear force (kg/g)[4]		0.26	0.26	0.25
Water holding capacity[5]		0.53	0.41	77.79**

[1] See Figure 1, page 30, for descriptions of treatment abbreviations.

[2] Maximum score, 5. Values are the means of 192 judgements, one per cooking method per package addition per replication by each of four panelists.

[3] Maximum score, 7. Values are the means of 384 judgements, one per cooking method per package addition per replication by each of eight panelists.

[4] Values are the means of 96 determinations, two per cooking method per package addition per replication.

[5] Values are the means of 144 determinations, three per cooking method per package addition per replication.

* Significant at $P < 0.05$

** Significant at $P < 0.01$

[1]A typical conventional institution roasting method is cooking meat in dry heat on a rack in a shallow open pan in a rotary gas oven at 177°.